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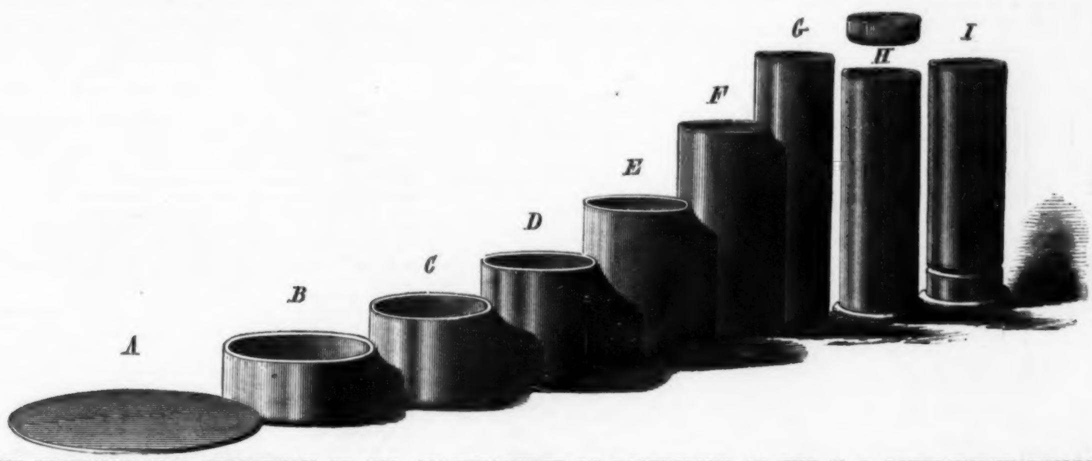
THE U. S. GOVERNMENT MECHANISM AT THE GREAT EXHIBITION.

THE U. S. Government building contains one of the main attractions of the Centennial, in the machinery from the Springfield Armory. The machines are shown in operation, and attract throngs of visitors, who eagerly watch them. Among the most notable of the special machines are those for making the cartridge cases, which stand in a row close to the entrance of the building, and are managed by girls.

The first operation is to cut out with dies the copper washer shown in our engraving at A. The next is termed the cupping, which transforms the form of the washer A into the form of the cup B, by forcing it through a die by means of a vertical plunger. Passing to another machine the cup B is again forced through a die, altering its shape from that of B to that of C; the process being continued through successive machines until the cartridge cases reach the form of G in our engraving, when they are ready to be operated upon by the case trimmer, a machine which trims off the ends of the cases to the length necessary to allow sufficient metal for the upsetting process, by which the head is formed. This leaves the case in the form shown in our illustration at H.

The cap which has been made by processes similar to those employed in the construction of the cases and above described, and which is shown standing above H, is then put into its position in the cartridge case, and the latter is crimped so as to fasten the cap in place, giving the case the finished appearance shown in our engraving at I.



THE INTERNATIONAL EXHIBITION OF 1876.—MANUFACTURE OF CARTRIDGES AT THE U. S. GOVERNMENT BUILDING.

STOCK MAKING.

The rifle stocks are made as follows: The wood, black walnut, is kiln dried, and the stock sawn out to the necessary shape, allowing sufficient surplus in the size for the finishing process. In this condition the wood is left to season. The first operation is facing off the stock on the part where the barrel fits. The second is termed the tip-turning; that is, turning the under or outside face of the part where the barrel fits. The stock is then ready for the butt-turning machine or lathe. To drive it, a dog composed of a piece of iron somewhat less in size than the finished end of the butt, and having several protruding spikes on one of its faces, is driven on to the end of the butt, and this driver fits into a socket which takes the place of the face plate of an ordinary lathe. In place of a tail stock, or dead centre, there is provided a standard fastened to a carriage sliding upon the lathe bed, the standard containing a washer revolving in a bearing. The washer is made in two halves, one half containing an oval slot to fit the outside or oval face of the tip, the other being flat to fit the face of the part where the barrel fits or rests. The halves of this washer are thrown open; the tip of the stock is passed through them; the butt end with the dog in position is then put into the socket-driving chuck, and held firmly back against it; then the washers are by means of a set screw clamped to the tip, and the cap securing the washers in the bearing is closed, and the stock or butt is chucked, ready to be turned. The bed of the lathe is similar to an ordinary flat surface lathe bed, and upon it there slides a carriage which carries the standard and the socket-driving chuck with the butt or rifle-stock placed in them, as above described. Immediately below the butt, and held by the same carriage, is a pattern stock or former made of cast-iron, and held in the same manner as is the wooden butt, the driving chucks of both being made so that they revolve in the same plane and at the same speed.

Independent of the bed and carriage, and in a permanent position, there is an upright frame, pivoted at the bottom or foot so that the top can swing. In this frame there is a wheel which revolves against the cast-iron former butt referred to above, so that when the upright frame is moved out of the perpendicular its weight presses the wheel against the cast-iron former, and thus causes the frame to partake of the irregular motion caused by the revolving of the iron former butt. In the same upright pivoted frame is a revolving cutter-head, the distance between the centres of the cutter-head and the wheel referred to (whose bearings are both horizontal and parallel one to the other) being the same as the distance between the centres of the cast-iron former butt and the wooden butt to be operated upon. The cutter-head is provided with twelve cutters arranged in sets of three, and each taking a different depth of cut. The cutter-head revolves at a speed of 3600 feet per minute, the cutters all being formed more or less on the turning-gouge principle. The machine being started, the former butt and the wooden one revolve slowly—say at about 80 revolutions per minute; the cutter-head, as above stated, at 3600 feet per minute. The frame is moved out of the perpendicular, and rests by its own gravity against the iron former butt, which revolves by friction the guide wheel. The carriage, which stands all on one side of the revolving cutters, then traverses past them until it stands all on the other side, the whole of the turning being performed during one traverse. The roughing cutters stand in advance on the cutter-head, and the finishing ones, protruding beyond the roughing ones, are placed behind them. The butt-turning process occupies in all about 3 minutes 15 seconds; the whole stock-turning and tip-facing and turning takes five minutes; the length of cut taken during the operation being about 13 miles, if placed in a straight line.

HE LOCK BEDDER.

The rifle stock now passes to the lock bedder, which cuts out the recess into which the lock fits. The general appearance of this machine is similar to a revolving head gang-drilling machine containing five spindles with their cutters. The rifle stock is chucked in its proper position in a fixed chuck or appliance, which ensures that the stock is correctly held; to the right of the stock and in a fixed position is an iron section of that part of the stock into which the lock is bedded, which iron section is used as a guide or former. The machine being started the first operation is to drill two holes, the drills entering until a stop prevents them from going any further, and hence ensuring uniformity and correctness in their depth. The position of these holes is regulated by a pin, which stands the same distance from the drill as is the centre of the recess in the iron former to the required centre of the recess for the lock in the stock being operated upon. The pin reaches the iron former a little in advance of the drill reaching the rifle stock, so that the position can be accurately set by swinging the machine head until the guide pin enters the hole in the iron former; then the drill is fed to its duty by hand. One hole being drilled, the spindles carrying the drill and the guide pin, which spindles are in the same frame and operate together, are raised, the machine head is swung one fifth of a revolution, and the first cutter comes in position to operate. On lowering the cutter spindle there descends with it, and slightly in advance of it, a guide pin in the iron former, and when the guide pin is well within the iron former the cutter reaches the surface of the wood, and is guided by the operator moving the head so that the guide pin travels all around the edge of the recess in the former. The motion of the guide pin and of the cutter being laterally identical, the operator has but to enter the cutter as far into the rifle stock as a stop provided for the purpose will admit, and then to move the frame carrying the guide pin and cutter so that the guide pin moves and touches all around the sides of the recess in the iron former. The recess in the rifle-stock will be then the exact counterpart, in size, form, and depth, of that in the pattern. The whole operation is but a repetition of the above, with the remaining cutters swung one after the other into position, the one iron former answering to regulate the lateral movement of them all. The speed at which the cutters revolve is about 8000 revolutions per minute. As soon, however, as each drill or cutter is swung out of position, it stops running, which prevents wear and tear. It is apparent that guiding the revolving cutters (which cut on their sides as well as on the end faces) to resharpen them reduces their diameter, and would, unless some provision were made for it, destroy the correctness of the work. This provision exists in the machine by the following means. In the spindles for driving the cutters there is a socket which will partly revolve, but which can be locked or retained in any position. When a cutter is new, and is consequently of full size, it revolves centrally in the socket, but after it has been reduced in size by resharpening, the socket is moved in its position in the spindle by being partly revolved. This causes the cutter to be sufficiently eccentric to the spindle to make up for its lack of correctness in diameter. As a guide in setting the amount of this eccentricity, the spindle is marked into ten divisions, each being denoted by a line which extends down to the junction of the socket and the spindle end. Upon the socket there is also marked a line, so that this one line acts as a pointer and the other ten as a rule. To cut out a recess complete and ready to receive a lock, occupies about a minute. This machine affords a superior specimen of designing performing many and very accurate operations with great exactitude, and being very simple to operate.

THE CORLISS BEVEL-GEAR WHEEL CUTTER.

By JOSHUA ROSE.

WHEN it was learned that Mr. Corliss proposed to communicate motion from the huge Corliss stationary engine to the several lines of shafting in the Machinery Hall of the Centennial, it was feared that gearing of sufficient strength could not fail to produce disagreeable noise and jar, especially when the high running speed was taken into consideration. The teeth on the fly-wheel of the engine revolve at a velocity of some 36 miles an hour. The bevel gears are about 5 feet six inches in diameter, and run at a velocity of about 18C revolutions, or 2245 feet, per minute, producing neither appreciable noise nor jar; not so much, indeed, as do the leather belts which communicate motion from the shafting beneath the flooring to the overhead shafting by means of which the machinery exhibited is operated. This is a remarkable and highly gratifying result, and the machine by means of which it was attained now stands near the large Corliss stationary engine in the centre of Machinery Hall, and is known as the Corliss Bevel-gear cutter. Though unpretending in appearance, it receives considerable attention at the hands of the mechanical portion of the visiting community. It was specially built to cut the bevel gears referred to; nor is it probable that it will find a large field of operation, since bevel gears of so large a size are not often used or cut. The frame of the machine occupies a floor space of 16 x 14 feet, and its construction is as follows:

The bevel wheels are chucked on a mandril, rigidly held in bearings in the frame. At the end of this mandril, and without the frame, is the index wheel, which is 15 feet in diameter, and contains upon its perimeter 216 index holes. Upon and around the edge of the rim of the index wheel are the cut teeth by which it is revolved. On one side of the index wheel is provided a suitable gearing attachment whereby to revolve it, and upon the same casting which carries this gearing is attached the index gauge, with a suitable stop plug for the index holes. Upon the same casting there is also provided a lug, which projects over the back rim of the index wheel, and a clamp operated by a suitable lever and eccentric movement, whereby the index wheel after adjustment is firmly clamped to the lug. The amount of movement is very small, so that the clamping shall not spring the index wheel out of true, while it is held so firmly as to effectively preclude the possibility of its movement under any practical contingency. The diameter of the index wheel being 15 feet, and that of the bevel-gears being 5 ft. 6 in., any variation from truth in the indexing of the wheel would be reduced about two and three quarter times, on the bevel. The holes, upon the index wheel are, however, practically true, since a minute measurement with finely adjusted calipers fails to denote any inaccuracy in their relative distances. Over the above-mentioned mandril, parallel with it, and at a right angle to the plane of the index wheel, is a radial arm, standing lengthwise in a line with the length of the teeth on the bevel gear requiring to be operated upon. Now, since the spaces between the teeth of a bevel gear are wider at one end than at the other, or in other words since the teeth themselves are thicker at one than at the other end of their length, it is obvious that when the bevel gear is set the radial arm adjusted

parallel to the side of one tooth will require moving laterally before it will stand parallel with the side of the tooth on the opposite side of the same space. And this lateral movement must take place from a centre in a line with the centre of the mandril carrying the bevel wheel. Otherwise the thickness of the teeth would not be made correctly. It is obvious also that one end of the radial arm must be arranged to lift and fall to accommodate varying sizes of bevel gears, the other end remaining stationary and true, with a centre standing true with the centre of the mandril on which the bevel gear is chucked, and hence true with the bevel gear itself. Furthermore, it is evident that the larger the size of the bevel gear the farther from the pivoted centre of the radial arm it must stand, and that the radial arm which carries the cutting tool must be adjustable to the turned face of teeth of bevel wheel. All these requirements are obtained by the following simple means. At a right angle to the centre line of the mandril stands the driving shaft of the machine, and on its end stands a small pinion cut out of the solid metal of the shaft. The centre of this pinion is a common centre to the mandril upon which the bevel gear is chucked (and hence to the gear itself), a common centre to the radial arm, so that it acts as a centre from which all the other movements of the machine are radially made. The radial arm is supported at the end near this pin, in two swivelled pin bearings forming a universal joint, thus permitting to the radial arm both lateral and vertical movement at one end, while at the same time the other end moves from the centre of the pinion. Beneath the radial arm is a cut rack, gearing with and into the pinion; this rack is attached to a carriage sliding upon the radial arm and extending along its underneath face, to a slide which carries the cutting tool. It is evident that the teeth of the rack being cut an accurate fit to those of the pinion, lateral movement would be impossible under ordinary circumstances. Provision for this movement is, however, made by fastening the teeth to the rack separately, each tooth swinging on a centre pin or bolt—there being sufficient space between the teeth at the bottom of the spaces between them to admit of the requisite lateral movement, so that if the radial arm is not fastened to the quadrant, hereafter to be referred to, it can be moved laterally, though the teeth of the rack do not move in the pinion teeth. Above the radial arm is a semicircular quadrant stationary with the frame, and standing true to the centre of the driving pinion, and through this quadrant stands the upper end of the radial arm, which has projecting from it a round steel pin. To the perimeter of the quadrant, and sliding upon it, there is a carriage carrying a former tooth; that is to say, a tooth of the shape which it is required to cut on the bevel wheel, but about three times as deep. Against the

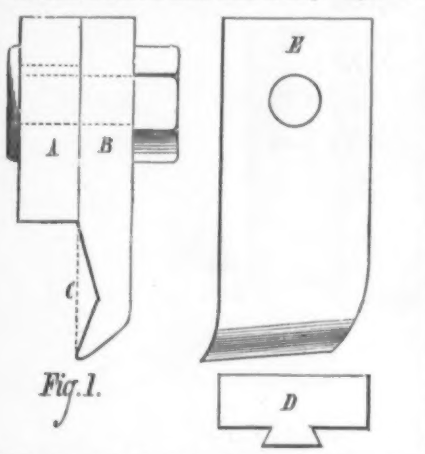


Fig. 1.

side of this former tooth the projecting pin of the radial arm is kept in contact by suitable means. The weight of radial arm is counterbalanced by weights connected by ropes to the pin end, while the carriage is provided with a feed gear which feeds the pin, at each stroke of the tool, along the former tooth; thus causing the movement of the radial arm in its descent to follow the precise shape of the former tooth. The former tooth employed for the teeth of the bevel wheels in question is $6\frac{1}{4}$ long; that is to say, has $6\frac{1}{4}$ inches of outline along which the radial arm pin moves. The teeth upon the bevel wheels are of the following dimensions: Depth, $2\frac{7}{8}$ inches; length, $14\frac{1}{4}$ inches; pitch, 4 inches; thickness at the pitch line $1\frac{11}{16}$ $\frac{1}{32}$ inches; amount of clearance in the spaces, $\frac{1}{16}$ inch; bare clearance top and bottom of the teeth, nearly $\frac{1}{8}$ inch.

The operation is as follows: The radial arm is raised out of the way, then the mandril is moved back, and the bevel wheel is put on the mandril, being bolted to its end face, as well as fitting the outside of the wheel hub into the true bore of the mandril. The bevel wheel is adjusted so that the teeth will stand in the correct position when the guide or index pin is in place, in one of the index holes in the perimeter of the index wheel. The radial arm is then lowered, and the mandril holding the bevel gear is moved outward towards the driving pinion the distance necessary, considering the depth of the former tooth as compared to the depth of tooth required on the bevel tooth. As the radial arm is lowered the carriage containing the former tooth and the feed gear slides down the quadrant, the exact position of that end of the radial-arm being adjusted by putting a tool in the tool-post (which latter stands on the under face of the radial arm, and above the bevel gear), and winding the tool along the bevelled face of the teeth until it will just touch the turned top of the teeth, from end to end. This being accomplished, the carriage is fastened to the quadrant and the guide pin on the end of the radial arm is brought into contact with the former tooth exactly at the pitch line of the latter. The tool is then adjusted so that its cutting edge stands exactly even with the pitch line of the bevel-gear teeth; a precaution which is absolutely necessary to obtain a correct shape of tooth. The radial arm guide-pin is then wound up to the top of the former tooth, and the machine is started. The pinion revolving moves the rack forward; the rack carriage sliding along the stationary radial arm by a suitable connection, operates the slide carrying the tool post and tool, which latter slide also moves along the under side of the radial arm. A rod attached to this slide operates a belt shipper, so that when the tool slide has travelled the necessary length of stroke, the motion of the pinion is reversed, and the return stroke is performed. The cutting operation is performed from the top of the tooth downwards, one side at a time, with a tool whose form at the cutting edge is identical in principle with that given in "Practical Mechanism," as a side tool for iron. The tool is fed to its cut at the end of the return stroke, and is by a simple contrivance moved a trifle laterally during the return stroke, so that the cutting edge shall not touch against the sides of the gear tooth, and thus become dulled. The cutting is performed on the down stroke of the tool, so that those sliding parts of the machine whose weight have any effect on the tool operate to balance the machine by being lifted while the tool is on the return stroke, assisting the tool by their weight during the forward stroke. The tool clamp or holder is a fixture on the sliding head, and is arranged so that its side face stands central to the driving pinion. Then the tool itself is made with a flat side face, and the cutting edge stands on an exact line with the side face, as shown in Fig. 1, in which A represents the tool post, B the tool and the dotted line, C the tool point even with the side face of the tool. The operator thus has but to keep the cutting edge of the tool even with the side face, and the tool will in that particular adjust itself. The finishing cuts, however, are taken very light, so that a tool will finish a wheel without being taken out to resharpen. In Fig. 1, D is an end view of the top end of the tool, the dovetail projection sliding in a recess cut in the tool post, and E is a side view of the tool. An oblong hole is provided in the tool post to permit of the adjustment of the tool in the direction of its projection from the tool post. During the roughing cuts the tool is fed at about $\frac{1}{16}$ inch to a stroke, and during the finishing cuts the feed is about $\frac{1}{32}$ inch per stroke, the cutting being performed very smoothly. The pinion and rack have a quick return motion, the pulleys being one pair belted together, each 20 inches in diameter, the other pair a 16 and a 24 inch pulley belted together. The ease with which the machine operates will be appreciated when it is stated that the driving belt on the machine is only $1\frac{1}{4}$ in. wide. The parts composing the machine are few, substantial, and have ample wearing surfaces, the design throughout being that the guiding movements are at least twice and a half as great as the tool movement, so that true as those guide movements are, the tool movement in every direction is at least twice and a half times as true; nor is it very easy, with ordinary care, to set the machine to perform incorrect work. Altogether, we may pronounce this machine one of the most perfect on exhibition.

MACHINERY HALL NOTES.

THE BELGIAN CORLISS ENGINE.

Among the Belgian exhibits in Machinery Hall is a stationary engine of the Corliss pattern, which is attracting considerable attention both for its excellence and beauty of design and the superiority of its material and workmanship. It is exhibited by P. Vanderkerchove, of Ghent, in Belgium, and is a condensing engine. The piston is 22 inches in diameter, and has a 55-inch stroke. The piston rod passes through the cylinders and connects directly with the air pumps and condensers, which stand in the rear. There are two cylinders connected to cranks at each end of the driving shaft, and standing at right angles. The fly-wheel is placed in the middle of the shaft, and between the cylinders, the Corliss valve gear being on the adjacent sides of the latter. On the perimeter of the fly-wheel are the cut teeth to communicate the power. The design of this wheel is very neat, notwithstanding its solidity, for its size. The rim is bolted together in segments, the arms being keyed therein. The hub is a separate piece, the arms also being keyed to it, thus completely avoiding the tension due to casting the wheel in one piece or even in halves. The crank pins are of steel, and are keyed into the cranks with round-edged steel keys, having but very little taper upon them, which renders them very powerful. The main shaft and cran s are also of steel, the latter being highly finished all over. The connecting rods have straps, jibs and keys of ordinary pattern, but are made of steel, as are also the piston rod, eccentric rods, eccentrics and eccentric straps. The brasses throughout the engine come brass and brass, as they should do. All the keys upon the engine are of steel, and have round edges, which strengthens the parts having the keyways cut through them. The crank pins and crosshead journals are of steel and hardened, and every bolt and nut on the engine is of steel, though, strange to say, the latter are not hardened. The fitting and finishing are first-class, and though one is tempted to find fault with the scraping of the side faces of the pillow blocks, the tasty contrast it presents to the other finished parts completely disarms criticism in this respect. The fitting of the connecting rods, crosshead and guides, and of the valve gear, is as superior as is the finish.

At the close of the Exhibition this engine is to be put in operation at the Mint, in Brussels.

DECORATION OF MACHINERY.

Among the notable features of Machinery Hall we may mention the absence of bright colors on the painted parts of the engines and machines. The predominating color is plain black, and next comes a dark brown approaching to a black. Varnish and fine lining are conspicuous by their absence, except it be in the pump annexe alone, where red, green, and chocolate colors, with white, red, and yellow lines, hold their own as before.

CASTINGS.

Another notable feature is the general excellence of the castings. The frames for the Belgian engine above described are excellent in this respect, but as a rule the Americans are far ahead, as a visit to the Buckeye stationary engine, Messrs. Poole & Hunt's exhibits, and the wood-working machinery of Messrs. Richards, London & Kelly, will attest. Poole & Hunt exhibit as a specimen of casting a solid pulley-wheel, 8 feet in diameter, with a 2 feet 6 inch face, there being a double set of arms, one set near each end of the hub. It is a very superior casting, and is entirely a *green-sand casting*. The same firm exhibit a 50-inch turbine, casing, and delivery pipe, the latter two being superb castings in every particular, and attracting much comment.

BAND SAWS.

Messrs. Richards, London & Kelly exhibit two specimens of band sawing which are exceedingly meritorious, not only for the elegance and delicacy of the design, but also for the smoothness of the sawing. The largest of these specimens has been named the Centennial Clock, since it contains a clock. It is 46 inches high, 34 inches wide, and from 5 to 9 inches deep. The other specimen is the handiwork of Mr. Perin, of Paris, of band-saw renown. At one of the band-sawing machines exhibited by this firm is working a mechanic who has taken a prominent part in our American Institute and other fairs for some years. McChesney, or the "Mohawk Dutchman," is the sobriquet by which he is known to the mechanical fraternity. He is a most expert band-saw operator, and evidences his skill by wearing decorative regalia, comprising a tiara, neck-tie, spectacles, and a huge belt buckle, the whole being made of fancy colored woods, and put together without glue or any other kindred assistance by his patent process of wood joining from the saw. The articles are composed of one hundred and fifty different pieces of wood. A peculiar specimen of sawing exhibited by this excellent mechanic is a chain 4 feet 6 inches long, composed of links about $2\frac{1}{4}$ inches long, the links being each double, and all solid from end to end, the whole having been cut from a single piece of black walnut 2 inches square by 4 inches long.

THE PUMP ANNEXE.

The pump annexe affords a contrast to every other part of the exhibition, and the pump interest is probably more largely represented than any other mechanical industry.

In the centre of the annexe is a huge tank of water, about 150 feet long by 50 feet wide. Ranged along the sides of this are the numerous hand and steam pumps of all sizes, grades and patterns, the latter having their delivery pipes ranging from an inch to a foot in diameter overhead, about 12 feet high, and all projecting over into the tank. At one end of the latter is an iron cataract 30 feet wide and 15 feet deep. At the top is a weir 35 feet from the surface of the water, over which weir an Andrews' centrifugal pump will throw thirty thousand gallons of water per minute. The tank and weir are supported on six iron columns. Add to this the numerous streams of water which will be dashing and pouring into the tank on all sides, and the effect will be grand in the extreme. The roaring of the waters will be aided by that of the pressure-blowers. At the end of the tank, opposite to the weir, a Crane pump throws a 2-inch stream of water almost from end to end of the tank. What with the falling water and the circulation of air caused by the pressure-blowers, this annexe promises to afford a pleasantly cool retreat during the heated term. Mr. W. B. Douglas displays six hundred pumps, while Messrs. Ramsey & Co. exhibit over seven hundred. The Heald & Cisco, Andrews, Knowles, Crane, Niagara, and other well-known steam pumps are here; while the Gould, Middletown, and other hand pumps are well represented.

THE CHIMES.

A late addition to Machinery Hall is a set of chimes, which are placed in a belfry over the main entrance. The set contains thirteen bells, to represent the thirteen original States of the Union. The bells have not been tuned, the object being to get a set of maiden bells, which object has been attained, with the exception of a slight defect in the tone of one bell. They are tuned in the key of C from C to seven, including flat seventh and sharp fourth. The tolling is performed by means of a key rack, the invention of Prof. Widdows, of the Metropolitan Church, at Washington. The largest bell weighs 2600 lbs. The chimes are played by the Professor for a half hour each after 9, 12 and 6 o'clock in the day. The castings were made by H. McShane & Co., who are the exhibitors of them.

ANOTHER CORLISS ENGINE.

In the centre of Machinery Hall, and between the large Corliss stationary engine and the Corliss bevel-wheel gear cutter, stands an unpretending Corliss engine, which has been running at Wm. Hooper & Co.'s factory at Baltimore for 16 years. This engine appears very little the worse for wear, and except in the construction of the fly-wheel and some minor details, such as having square-edged keys, is in design an exact *fac-simile* of the Belgian Corliss Engine which is attracting so much attention.

M'NAB & HARLIN.

To the left of the Corliss engine Messrs. McNab & Harlin display two large show-cases filled with oil cups, cocks, globe valves, and gas-fittings, some very finely finished and others in the castings; the former are good specimens of workmanship, while the latter are excellent.

COMPOUND HORIZONTAL ENGINES.

Jacob Nailor, of Philadelphia, has in position a pair of compound horizontal engines, the high-pressure cylinders being 8 x 18 inches, the low-pressure 15 x 18 inches, both cranks being on one throw. These engines are fitted with plane slide valves, the connecting-rod straps being held to the rods by bolts, and the wear in the length being compensated by placing the keys at one end on the outside, and on the other end on the inside, of the brasses. The air-pump is a plunger pump operated by an eccentric. Decorations are here studiously avoided, the clean appearance of the cylinder-jackets or lagging and the general finish impressing the beholder with neatness.

This firm also exhibit an engine having a steam cylinder 18 x 36, with a Cooper & Emory balanced slide-valve. The engine is notable for the broadness of its wearing surfaces, rendering it very substantial, and enabling it to run at a high speed without suffering undue wear. Their entries also include an engine with 12 x 14 and one 6 x 8 inch steam-cylinders, both being vertical engines, and having steel connecting-rods.

The Corliss engine driving the shafting for Machinery Hall runs smoothly to an unexpected degree. The 30-foot gear wheel engaging its ten-foot pinion gives a murmuring sound, producing what may aptly be termed mechanical music, while so quietly are the motions of the working parts of the engine performed, that we realize as we watch them the poetry of mechanical motion.

THE BUCKEYE ENGINES.

The Buckeye Engine Co. exhibit a high-pressure engine of 95 horse-power, the steam-cylinder being 16 x 32 inches. The engine is fitted with Thompson's automatic cut-off balanced valve, which was illustrated in a former issue of the Scientific American. The fly-wheel of this engine, which is 10 feet in diameter, with a 25-inch face, is cast with the rim and arms all solid, the tension due to the contraction which takes place during the cooling of the casting having been accommodated by casting the hub split in three places. These points were subsequently filled with lead, and the outside of the hubs being turned in the lathe, two wrought-iron collars were shrunk on.

BURLEIGH AIR-COMPRESSOR.

The Burleigh air-compressor is exhibited in a new form. The steam and air cylinders are overhead, the crank shaft below. The size of the steam-cylinder is 18 x 24 inches, and it is fitted with the Putnam Machine Co.'s balanced poppet-valve movement. The two air-cylinders which stand in a line with the steam-cylinder are single acting, each being 20 x 24 inches, and having one receiving and one discharge valve. The base of the whole machine occupies a floor space of 8 x 6 feet. The fly-wheel is 9 feet diameter with a 6-inch face, and weighs 7000 lbs., the total weight of the engine and compressors being 19 tons. The design is a very compact one, and yet any part can easily be got at if necessary. J. R.

LOCOMOTIVES AT THE EXHIBITION.

WE illustrate on this page two of the locomotives belonging to the exhibit of the Baldwin Locomotive Works, of Philadelphia, at the International Exhibition. The specifications of the locomotives are as follows:

"CONSOLIDATION" ENGINE.

Freight locomotive, "Consolidation" pattern, for the Lehigh Valley Railroad, 4 ft. $8\frac{1}{2}$ in. gauge. Fuel, anthracite coal.

Cylinders.

	Feet.	Inches.
Diameter	1	8
Stroke of piston	2	..
Length of steam ports	..	4
Width of " "	..	$1\frac{1}{4}$
" exhaust ports	..	$2\frac{1}{2}$
Travel of valve	..	$5\frac{1}{2}$
Outside lap of valves	..	$\frac{3}{4}$
Inside lap "	..	$\frac{1}{32}$
Exhaust nozzles double variable.		

Wheels.

	Feet.	Inches.
Diameter of driving-wheels	4	$2\frac{3}{8}$
" truck wheels	2	6
Distance between centres of front and rear driving-wheels	4	9
Total wheel-base of locomotive	22	10
" " " and tender	46	2
Diameter of driving-axle journals	..	7
Length " " "	..	8
Diameter of main crank-pin bearing	..	5
Length " " "	..	5

Boiler.

	Feet.	Inches.
Outside diameter of smallest ring of boiler	4	6
Thickness of boiler-plates (iron)	..	$\frac{3}{8}$
Number of tubes, 198.		
Length "	11	..
Outside diameter of tubes	..	2
Length of fire-box inside	9	10
Width " "	2	$9\frac{3}{4}$
Depth " " (sloping)		$44\frac{1}{2}$ to 55
Thickness of fire-box plates (steel), sides and back	..	$\frac{5}{16}$
" flue sheet	..	$\frac{1}{2}$
" crown-sheet	..	$\frac{3}{8}$
Square feet of grate surface	$27\frac{9}{16}$	..
" heating surface in fire-box	149	..
" " " tubes	1,132	..
Total square feet of heating surface	1,281	..

Weight.

Weight of engine in working order ......100,000 lbs.
" " on driving wheels ...... 88,000 "

REMARKS.—Locomotives of this class have been used on the Lehigh Valley Railroad since 1866, in which year the locomotive "Consolidation," from which the class has taken its name, was built by the Baldwin Locomotive Works, in accordance with the plan and specifications furnished by Mr. Alexander Mitchell, then Master Mechanic of the Mahanoy Division of that line.

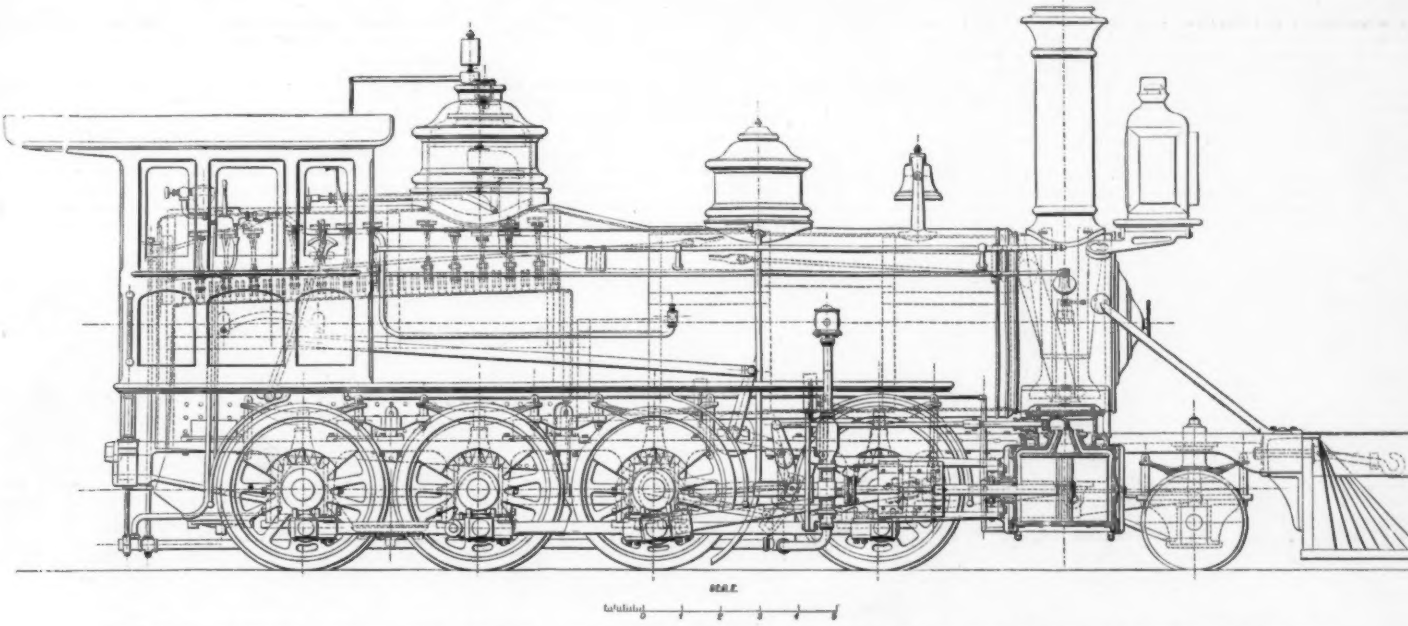
On the Wyoming Division of the same railroad, from Sugar Notch to Fairview, the grade is 1 in 55 (96 ft. per mile) for 12 miles in length, combined with curves of 8 and 10 degrees radius. The curves are frequent, and there are but two tangents, each less than one mile long, in the whole 12 miles. Up this incline engines of this class can take 40 loaded four-wheeled coal cars. The usual train is 35 such cars, which are taken at a speed of 12 miles per hour. The cars weigh, each, 3 gross tons, 8 cwt., and carry, each, 6 gross tons of coal. The weight of train, therefore, which a "Consolidation" engine takes up the grade, combined with curves as stated, is from 329 to 376 gross tons.

On the Mahanoy Division, over maximum grades of 126 feet per mile, the maximum load is 35 loaded four-wheeled coal cars (329 gross tons of cars and lading) and the usual load 25 loaded four-wheeled coal cars (235 gross tons of cars and lading). On the same division, over a grade of 76 ft. per mile, one of these engines draws a maximum train of 140 empty four-wheeled cars (476 gross tons) at a speed of 8 miles per hour. Its usual train is 100 empty cars (340 gross tons). Compared with the ten-wheeled pattern of locomotive (cylinders, 18 x 24; driving wheels, 4 and $4\frac{1}{2}$ feet diameter; weight on driving wheels, about 60,000 lbs.) the performance is as shown in the following table:

	Grade 126 per mile. Gross tons of train.	Grade 76 per mile. Gross tons of train.
Maximum load of "consolidation" locomotive	329	476
" " ten-wheeled locomotive	235	340
Usual load of "consolidation" locomotive	235	340
" " ten-wheeled locomotive	169 to 200	221

Consumption of fuel, "consolidation" engine, $3\frac{3}{4}$ tons daily.
" " ten-wheeled " $3\frac{1}{4}$ " "

The ordinary repairs for a series of years have been one mill per mile greater for the "consolidation" than for the ten-wheeled engine.



THE INTERNATIONAL EXHIBITION OF 1876.—"CONSOLIDATION" LOCOMOTIVE, FROM THE BALDWIN LOCOMOTIVE WORKS.

"AMERICAN" LOCOMOTIVE.

Passenger locomotive, "American" pattern, for the Central Railroad of New Jersey, 4 ft. $8\frac{1}{2}$ in. gauge. Fuel, anthracite coal.

Cylinders.

	Feet.	Inches.
Diameter	1	5
Stroke of piston	1	10
Length of steam ports	1	3
Width " "	..	$1\frac{1}{4}$
" " exhaust ports	..	$2\frac{3}{8}$
Travel of valve	..	$5\frac{3}{8}$
Outside lap of valves	..	$\frac{3}{4}$
Inside " " "	..	$\frac{1}{32}$
Exhaust nozzles, single high.		

Wheels.

	Feet.	Inches.
Diameter of driving-wheels	5	2
" " truck-wheels	2	4
Distance between centres of front and rear driving-wheels	8	6
Total wheel-base of locomotive	22	5
" " " " and tender	44	$2\frac{1}{2}$
Diameter of driving-axle journals	..	7
Length " " "	..	8
Diameter of main crank-pin bearing	..	$4\frac{1}{4}$
Length " " " "	..	$4\frac{1}{4}$

Boiler.

	Feet.	Inches.
Outside diameter of smallest ring of boiler	4	..
Thickness of boiler plates (steel)	..	$\frac{3}{8}$
Number of tubes, 163.		
Length " "	11	3
Outside diameter of tubes	..	2
Length of fire-box inside	8	6
Width " " "	2	$9\frac{3}{4}$
Depth " " " (sloping)	..	39 to 53
Thickness of fire-box plates (steel) side sheets	..	$\frac{1}{4}$
" " " " " back "	..	$\frac{5}{16}$
" " crown sheets	..	$\frac{3}{8}$
Thickness of flue sheets	..	$\frac{3}{8}$
Square feet of grate surface	24	..
" " " heating surface in fire-box	112	..
" " " " " " tubes	953	..
Total square feet of heating surface	1,065	..

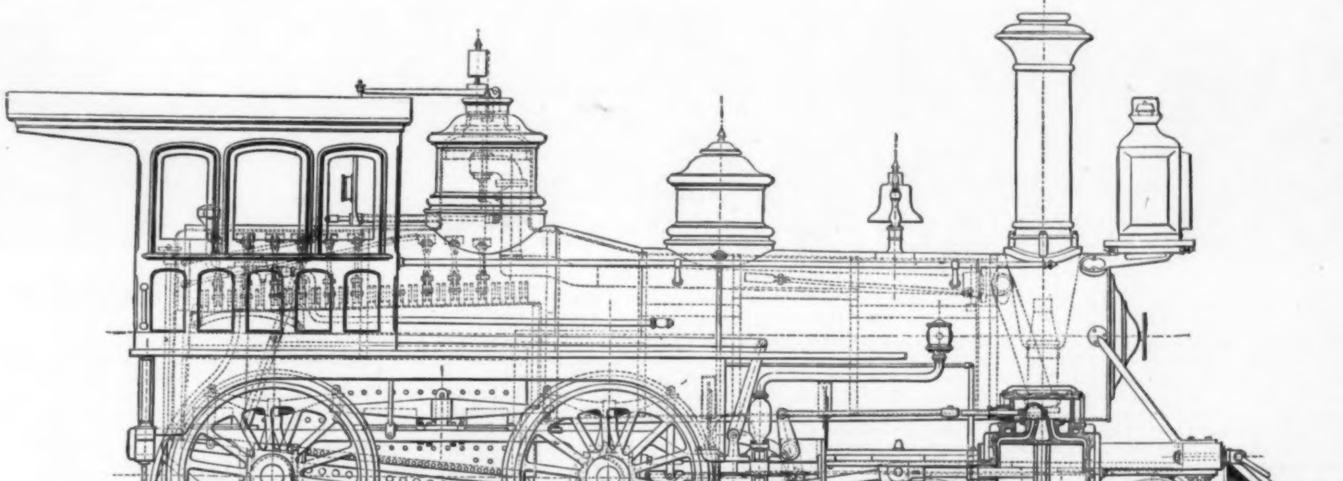
Tender.

	Feet.	Inches.
Number of wheels, 8.		
Diameter of "	2	6
" " tender-axle journals	..	$3\frac{1}{2}$
Length " " "	..	7
Capacity of tank	2,200 gallons.	

Weight.

Weight of engine in working order ......75,000 lbs.
" " " on driving-wheels ......51,500 "
" " tender, empty ......20,500 "

Railroad Gazette.



THE INTERNATIONAL EXHIBITION OF 1876.—"AMERICAN" LOCOMOTIVE, FROM THE BALDWIN LOCOMOTIVE WORKS.

THE ART GALLERY.

The most imposing and ornate of all the structures designed for the Exhibition is Memorial Hall, built at a cost of $1,500,000, by the State of Pennsylvania and city of Philadelphia. This is to be used during the Exhibition as an Art Gallery, after which it is designed to make it the receptacle of an industrial and art collection similar to the famous South-Kensington Museum, at London. It stands a short distance northward of the Main Building, and is in a commanding position, looking southward across the Schuylkill over Philadelphia. The design is modern Renaissance. It covers an acre and a half, and is 365 ft. long, 210 ft. wide, and 59 ft. high, over a spacious basement 12 ft. high. A dome, rising 150 ft. above the ground, surmounts the centre, capped by a colossal bell, from which rises the figure of Columbia. On each front of the buildings the entrances open into halls, 82 ft. long, 60 ft. wide, and 53 ft. high, decorated in modern Renaissance. These, in turn, open into the centre hall, 83 ft. square, the ceiling rising over it 80 ft. in height. From the east and west sides of this centre hall extend the galleries, each 98 ft. long, 48 ft. wide, and 35 ft. high. These galleries admit of temporary divisions for the better display of paintings, and with the centre hall form a grand hall 287 ft. long and 83 ft. wide, capable of comfortably accommodating 8000 persons. This is nearly twice the dimensions of the largest hall in the United States. From the galleries doorways open into two smaller galleries, 89 ft. long and 28 ft. wide. These open north and south into private apartments connecting with the pavilion-rooms, and forming two side-galleries 210 ft. long. Along the whole length of the north side of the main galleries and central hall extends a corridor 14 ft. wide, opening on its north line into a series of private rooms, twenty-three in number, designed for studios and smaller exhibition-rooms. All the galleries and the central hall are lighted from above; the pavilions and studios from the sides. The pavilions and central hall are designed especially for the exhibition of sculpture. This fine building gives 75,000 square feet of wall space for paintings, and 20,000 square feet of floor space for statues, etc. The skylights throughout are double, the upper being of clear glass and the under of ground glass.

THE MAIN BUILDING AND THE ART GALLERY.

It will be remembered that the opening ceremonies of the great Exhibition on May 10th, 1876, took place in the open air in the space between the fronts of the Main Building and the Art Building. Our views, which are from *Harper's Weekly*, represent the fronts of the structures respectively, as they appeared on that memorable occasion. For a detailed account of the interesting proceedings on the opening day, reference is made to Supplement No. 22. We subjoin a few particulars concerning the structures shown in our engravings.

THE MAIN BUILDING

Is the largest edifice ever used for a world's fair, and has probably been put up in a shorter time than any other structure, except some of its sister buildings on the Centennial grounds, like the Art Gallery, built by the same contractor, Richard J. Dobbing. It was as recently as last May, 1875, that the work of erecting the columns for the Main Building was begun, and now a magnificent edifice has been completed, covering over twenty acres of ground, using nearly 8,000,000 pounds of iron in its columns and girders, 7,000,000 feet of lumber, four miles of water-piping, and requiring the services of an army of 3000 mechanics and laborers.

The foundations of the building are piers of masonry, and the superstructure is composed of wrought-iron columns, which support wrought-iron roof-trusses. Lengthwise of the building the columns are twenty-four feet apart. There are 672 columns in all, the shortest being 23 feet and the longest 125 feet in length. The building being a temporary construction, both columns and roof-trusses are so designed that they can easily be taken down for re-erection elsewhere. The sides of the building, for the height of seven feet from the ground, are finished with brickwork, with panels between the columns, and above the seven feet with glazed sash.

AREA OF THE MAIN BUILDING.

The areas covered by the Main Building are as follows:

	Square feet.	Acres.
Ground floor	872,320	20.02
Upper floors, in projections	37,344	.85
Upper floors, in towers	26,344	.60
Total	936,008	21.47

THE INTERIOR.

The general arrangement of the ground floor shows a central avenue, or nave, 120 feet in width, and extending 1832 feet in length. It is the largest avenue of that width ever introduced into an exhibition building. On either side of this nave there is an avenue 100 by 1832 feet long. Between the nave and side avenues are aisles 48 feet wide, and on the other side of the building smaller aisles 24 feet in width. In order to break the great length of the roof-lines three cross-avenues, or transepts, have been introduced, of the same widths and in the same relative positions to each other as the nave and avenues running lengthwise—namely, a central transept, 120 feet in width by 416 feet in length, with one on either side of 100 feet by 416 feet, and aisles between of 48 feet. The intersection of these avenues and transepts in the central portion of the building results in dividing the floor into nine open spaces, free from supporting-columns, and covering in the aggregate an area of 416 square feet.

THE DECORATION.

The interior decoration of the building is in excellent taste. The walls and roof are painted a very pale blue, with a variegated border encircling them, the prevailing color of which is a bright carmine. A row of circular windows extends around below the ventilators and skylights of each avenue and aisle. These are filled with what appears to be richly stained glass in variegated designs. The effect is very bright and pleasing, but the "stained glass," which, if it were real, would have cost hundreds of thousands of dollars, is nothing more nor less than cheap muslin lightly painted and pasted over plain glass.

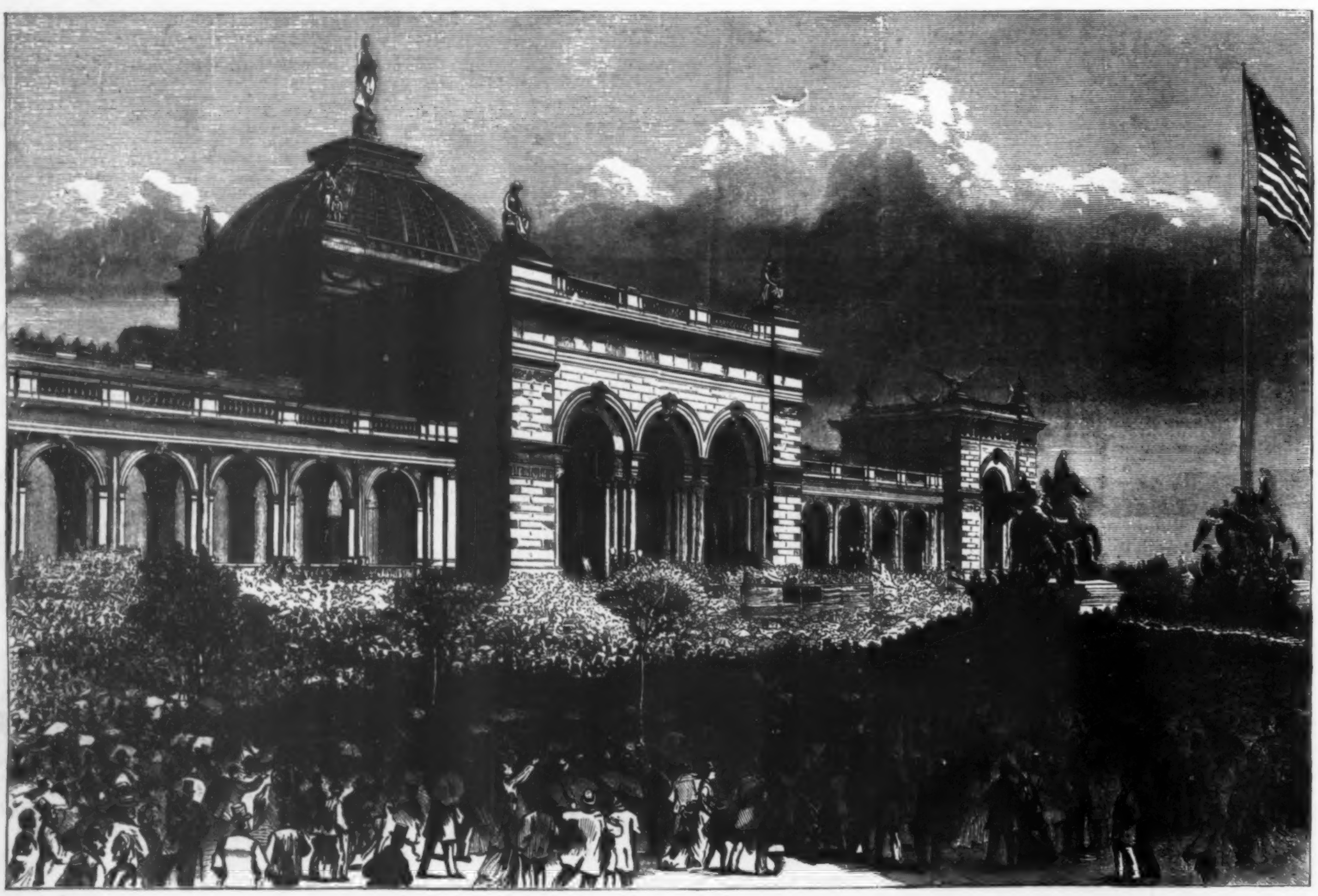
Another feature of the interior work that deserves particular attention, is the painting of the iron pillars supporting the roof girders. These pillars are only twenty-four feet apart, but so judiciously are they made, and so artfully are they painted, that they appear very slender, and interpose no obstacle to the sight. This result has been accomplished by painting the columns in the same pale blue tint that is on the walls and roof, and then putting on a narrow ribbon of bright color down the centre. At a short distance the effect is wonderful. The columns appear to be no wider than this band of bright color.

MEASUREMENT OF THE MAIN BUILDING.

The following figures, giving the dimensions of the main building from measurements taken from centre to centre of supporting columns, are not easily remembered, but they will be found useful for reference:

	Feet.
Length of building	1,880
Width of building	464
Central avenue, or nave—	
Length	1,832
Width	120
Height to top of supporting columns	45
Height to ridge of roof	70
Central transept—	
Length	416
Width	120
Height to top of columns	45
Height to ridge of roof	70
Side avenues—	
Length	1,832
Width	100
Height to top of columns	45
Height to ridge of roof	65
Side transepts—	
Length	416
Width	100
Height to top of columns	45
Height to ridge of roof	65
Central aisles—	
Length at east end	744
Length at west end	672
Width	48
Height to roof	30
Side aisles—	
Length at east end	744
Length at west end	672
Width	24
Height to roof	24
Central space or pavilion—	
Ground plan (square)	120
Height to top of supporting columns	72
Height to ridge of roof	96
Towers over courts—	
Ground plan (square)	48
Height to roof	120
Corner towers—	
Ground plan (square)	24
Height to roof	75

Considering the size of this structure, its cost has been very cheap. Mr. Dobbins, the contractor, will receive for it $1,600,000. One day a number of carpet manufacturers were going through the building, arranging for their display. Mr. Pettit asked one of them what it would cost to carpet twenty acres of ground with the best carpet. "About $2 a square foot," was the reply. "Then this building cost less to build than you would charge to carpet the earth it covers," he replied, after making a little calculation. "The price paid for this building per horizontal foot was about $1.83."



THE INTERNATIONAL EXHIBITION OF 1876.—THE ART GALLERY ON THE DAY OF OPENING

Epsom salts is very largely manufactured in Philadelphia from the mineral called kryolite. One house has the monopoly of this substance, which is obtained from the coast of Greenland. During the year ending June 30, 1874, the value of the firm's importations of Greenland kryolite, all entered at Philadelphia, was $17,870. In the succeeding month of August they brought $14,866 worth; in September, $18,587 worth; in October, $9,087 worth; in November, $18,071 worth. The importations thus far are valued at over $80,000.

[San Francisco Mining and Scientific Press.]

TELLURIUM.

CONSIDERABLE excitement has been raised by certain interior papers of this State by the announcement of the discovery of tellurium, and the statement that it was worth $3000 per pound. In several counties in the interior this has set a number of prospectors at work with the expectation of making a fortune in a very short space of time, before the supply should be so increased as to reduce the price. Numbers of samples of ore, supposed to contain tellurium, have been sent to assayers in this city and elsewhere by sanguine claim-holders, who think they have a good thing. We are sorry to dispel the illusion as to the value of the article, but are, at the same time, happy to avail ourselves of the opportunity to explain to our mining friends, who may be making foolish ventures, exactly what tellurium is, how to test its presence, and how much it is worth. With this object in view, we interviewed Mr. Henry G. Hanks, the well known chemist and assayer of this city, who gives us the following information concerning the substance:

Tellurium is a white metal, brittle and easily fusible. Its equivalent or combining weight is 64.2 in the old system of notation, which is doubled in the new. The symbol used by chemists to express this element is "Te."

Tellurium was discovered and named by Klaproth. The specific gravity of the metal is 6.257.

The name tellurium is derived from the Latin word *Tellus*, the earth. The word "telluric" has no reference to the metal, but implies pertaining to the earth.

This metal is very rare on the earth, but exists in a gaseous state, probably combined with hydrogen, in the atmosphere of some of the fixed stars, as revealed by the spectroscope. It is particularly noticeable in Aldebaran. I think I am not mistaken in stating that it has not yet been discovered in the sun.

Tellurium, as far as known, is found only in ten rare minerals, as follows (the figures showing the percentage of tellurium in each):

1. Altaite, combined with lead	38.3
2. Calaverite, combined with gold and silver	56.0
3. Hessite, combined with silver	37.2
4. Joseite, combined with sulphur, selenium, and bismuth	15.93
5. Nagyagite, combined with sulphur, lead, silver, gold, and copper	30.52
6. Petzite, a variety of hessite (No. 3)	
7. Sylvanite, combined with antimony, gold, silver, and lead	44 to 60
8. Tellurium, native, nearly pure	
9. Tetradymite, combined with silver and bismuth	33 to 48
10. Tellurite, doubtful	

Tellurium is not only fusible, but is volatile, and may be sublimed in a glass tube without change. When exposed to high temperatures it becomes oxidized to tellurious acid ($Te\,O_2$), giving off dense white vapors. If the experiment is made in a piece of clean charcoal before the blowpipe flame, a coating is formed on the coal. If this coating is touched by the point of the reducing flame, it disappears, tinging the flame at the same time bluish-green. This reaction is characteristic. Any substance containing telurium imparts a red color to boiling concentrated sulphuric acid. By these tests tellurium may be detected with certainty in any substance which may contain it.

The statement lately made in the papers, that a firm in San Francisco had paid $3000 for one pound of tellurium, is evidently a mistake.

At the rate of 51 cents per gram—at which price it is quoted in German price-lists—a pound would only be worth $231.54. But when it is known that dealers make large discounts on their printed list of prices, and that wholesale rates are much less than retail, it is evident that so large a quantity as a pound could be bought for a much less sum.

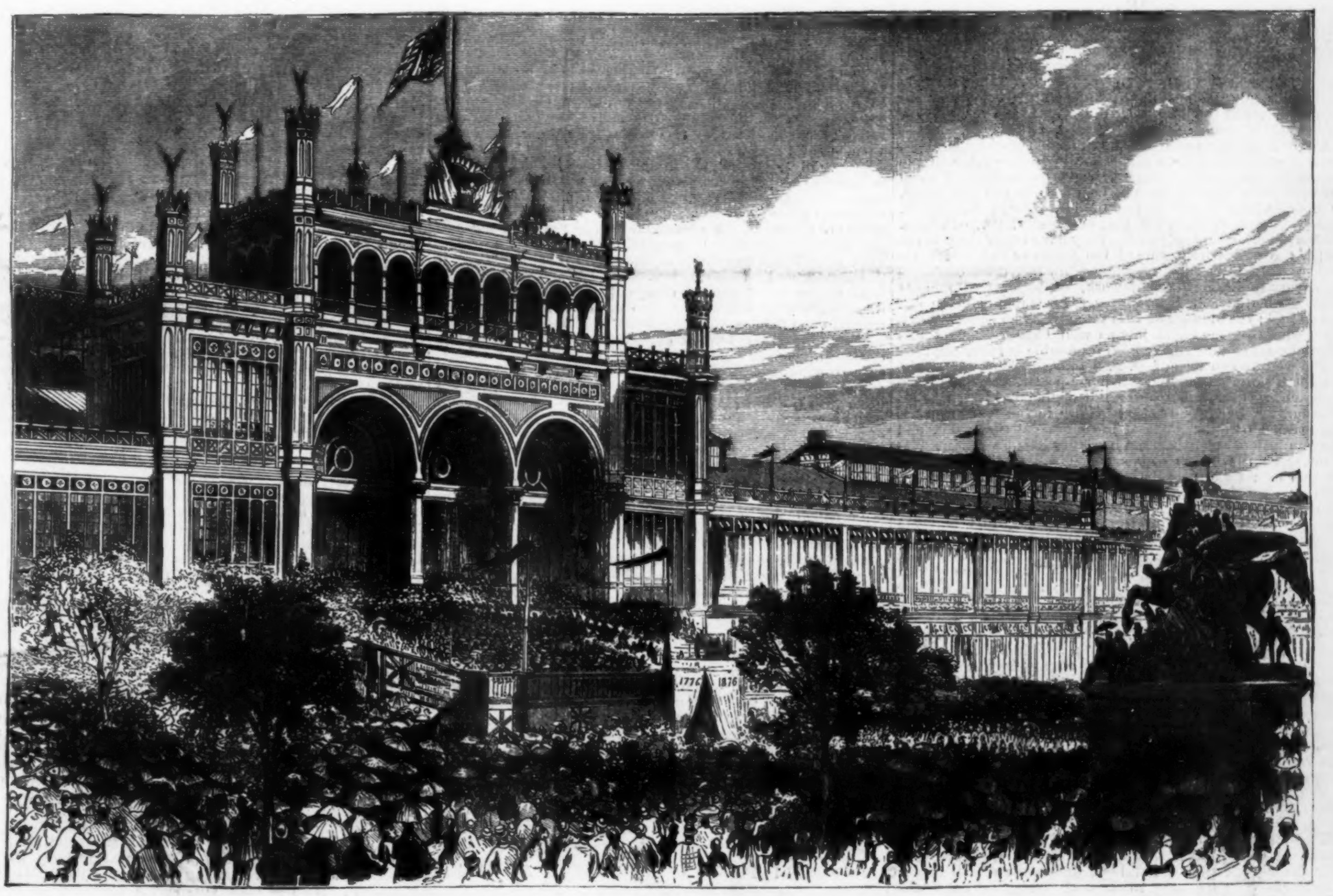
Tellurium has absolutely no use in the arts. It is only prepared in small quantities as a chemical curiosity. All the reactions of the metal can be obtained by students from some of the minerals containing it, which are comparatively cheap. Like every other manufacture, its production is governed by the laws of supply and demand. In this case both the supply and demand are small; hence there is no inducement for its production, and those who do produce it naturally realize all they can from their small sales.

As an illustration of how the price of a commodity decreases when inducements are offered for its large manufacture, I have only to cite the metal sodium, which a few years ago was very high-priced for the same reason that tellurium is at the present time, athough the supply was enormous, the dispersion of sodium being greater than that of almost any other substance. When the demand increased—it being required for the manufacture of sodium amalgam, and for the reduction of aluminum—new methods of producing it were discovered, and it has now become quite cheap and abundant.

Tellurium is found in considerable quantities in Schemnitz, Hungary, and in the silver-mines of Sadovinski in the Altai, associated with silver and lead. At the mine "Maria Loretto," in Transylvania, in sandstone, with quartz, pyrites, and gold. From this locality (Transylvania) the name sylvanite is derived.

In the United States it has been discovered in Virginia and North Carolina associated with bismuth (tetradymite).

Fine specimens come to us from the American Mine, Sunshine District, Boulder County, Colorado.



THE INTERNATIONAL EXHIBITION OF 1876.—THE MAIN BUILDING ON THE DAY OF OPENING.

THE DHU HEARTACH LIGHTHOUSE.

Paper read before the Institution of Civil Engineers.

By Mr. DAVID ALAN STEVENSON, B.Sc.

THIS lighthouse tower, the erection of which had been recently completed by the Commissioners of Northern Lighthouses, occupied an important position with regard to the navigation of the west coast of Scotland. The rock was fourteen miles from the Shore station at Isle Earraid, in Mull, the nearest land. The main rock was a mass of trap, 240 ft. long and 130 ft. broad, with a rounded top rising to 35 ft. above high-water spring tides, and it was surrounded on all sides by deep water. The tower was a parabolic frustrum surmounted by a plain cavetto, abacus, and parapet, the upper course of which was 107½ ft. above the foundation. The diameter of the tower at the base was 36 ft., that of the top being 16 ft. The doorway was 32 ft. above the foundation, and there were six compartments, affording accommodation equal to 5500 cubic feet. The whole weight of the tower was 3115 tons, of which 1840 were contained in the solid base. The tower was constructed of gray granite, of excellent quality, quarried in the immediate vicinity of the Shore station.

Authority to begin the works was obtained in March, 1867, and, short as the season's work necessarily was, the excavation of the foundation was begun, and the first tier of the malleable iron barrack for the accommodation of the workmen, deemed necessary on account of the difficulty of landing, was erected. The winter of 1867 was employed in building the attending steamer, lighters, cranes, and other plant.

Landings were effected on thirty-eight days in 1868, during which the barrack was completed, and three-fourths of the foundation excavated. The shore works at Earraid were vigorously carried on, the quarries fully opened out, part of the foundation course was dressed, and the dwelling-houses were far advanced.

In 1869 landings were effected on sixty days. On the 24th of June the first stones were landed. Part of the third course had been completed when a gale arose, on the 8th and 9th of July, which tore up fourteen stones, each weighing two tons, which had been laid in Portland cement and joggled; eleven of them were washed off the rock into deep water, and this at a level of 35½ ft. above high water. Other proofs of the extreme violence of the sea at Dhu Heartach were recorded in the paper. A description was given of a submarine valley, or funnel-shaped track, to the westward of Dhu Heartach, which the author suggested might account for the abnormal sea at this situation. By the end of this season the fifth course had been completed. On shore dwellings for five families had been finished, and seventeen courses of the tower were dressed. The stones were built dry on a fitting platform, were then transferred to lighters, and towed out to the rock. The lighters carried 16 tons, and the steamer took out two at a time. Three hours were occupied on the journey out, but on exceptionally fine days two trips were made. On the rock the tramway and all the cranes were worked by steam, the stones being built in as soon as they were landed, in case a gale should spring up. Square ribbon, cast and malleable iron joggles, were used in various parts of the work.

The number of days on which landings could be made in 1870 was sixty-two, and by the end of this season the 31st course was finished. The works ashore were pushed on, and contracts for the lantern and apparatus were entered into. In 1871, landings on thirty-seven days were effected, the masonry of tower was completed, as also the whole of the dwelling houses at Earraid.

The fitting up of the lantern, optical apparatus, fog-bell, and internal fittings were executed in 1872. Two Portland cement beacons at Earraid were erected. The light, which was 145 feet above the sea, giving a range of eighteen nautical miles, was exhibited on November 1st. The apparatus was first order dioptric showing a white light, except over an arc of seven points, which was red. The fog-bell was made distinctive from that of Skerryvore. In addition to the lighthouse, the works included nine dwelling-houses, for the lightkeeper and crews of the attending steamers. The cost might be approximately apportioned thus:—Tower, lantern, apparatus, and fog-bell machinery, £65,784 9s. 7d.; shore establishment, £10,300; total, £76,084 9s. 7d. The author pointed out that useful comparison with other towers was impossible, on account of the variety of circumstances, but he believed the cost would compare favorably with towers in less exposed situations.

THE Quebec *Mercury* says: "The flies which fell in a shower at Rivière du Loup lately, are classed by Mr. Belanger, Curator of Museum of Natural History to the Laval University, under the order of *neuropteres*, or dragon-fly, which deposits its larvæ beneath the water, and is supposed to belong to the Perlides family, probably the *Capnia pygmæa*. Fitch says they are frequently met with in New-York in the month of February, but Canadian naturalists are not yet familiar with it, and its popular history is thus given by an old *habitant*: They are seen in certain parts of Lower Canada in greater or less abundance, every year, about the middle or end of March. The farmers know it as the *bête à sucre*, or 'sugar-fly,' and judge of the probable sugar yield by the number of flies about when they are tapping the maples. On the south shores of the Island of Orleans they are annually observed about the ice and make north for the land, contrary to the grasshoppers, which always make south and drown themselves in the river. After leaving the shore ice, the sugar-flies take shelter in thousands on the trees near the roads, and thence they travel over the snow.

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THE INTERNATIONAL EXHIBITION OF 1876.

STEAM ENGINES.

No 8.

ON the above subject there is material enough at the Exhibition upon which to base a considerable volume without doing more than to touch upon the most salient points in the many machines of this class on exhibition. I must, therefore, notice only the most interesting features and prominent improvements in them, in order to permit of the vast mass of other kinds of machinery being treated of in their turn.

A very noticeable feature in the collection of steam-engines, and one which must be a matter for legitimate pride on the part of the originator, is that a very large number of them have either the peculiar form of bed-piece, or the valve-gear, or both, which is the design of Mr. George H. Corliss. Messrs. Robert Wetherill & Co., of Chester, Pa., exhibit a Corliss engine, completely such. They have taken the pains to polish the entire front side of the frame or bed, which, together with the excellent workmanship put upon it, makes up a very creditable piece of work. A boiler feed pump is exhibited by the same firm, however, for which so much can not be said; the plunger of it is actuated by an eccentric in a place where a crank could just as well have been used and which would certainly have been preferable in every way.

The well-known firm of H. F. Blandy, of Zanesville, Ohio, exhibit a portable engine of 8 horse-power, a semi-portable of 20 horse-power, and a horizontal engine of 13 in. x 20 in. cylinder. A remarkably good feature in the two former is the method of attachment of the engine to the boiler, and the method of resisting the working strains of the machine. This is by no means novel, having been patented by this firm for a considerable time past, but it is of such sterling importance as to merit more than a passing notice. The feed-water heater (tubular) is in the form of a long cast-iron cylinder of considerable diameter, and is made to subserve the purpose of a hollow girder, to which both the cylinder and the main shaft bearing is attached; the whole of the working strains being transmitted through this very appropriate form of engine frame. These are bolted into the boiler footing pieces, which have planed seats, upon which are fitted legs which project from this feed-heater frame; and the latter, carrying the engine complete, except the outer main shaft bearing, is bolted to these footing pieces. In this way the entire engine may be removed from the boiler without disturbing any of the bolts which pass through the boiler plate, and as the legs are allowed to adjust themselves upon their planed seats during variations of temperature, the boiler is relieved from all strain coming either from change of temperature or the working strains of the machine. This construction will be regarded by engineers as far in advance of those forms of portable engine which make the boiler shell act the part of engine frame. Their stationary horizontal engine has the appearance of a good, plain, substantial machine. The admission gear is a plain slide valve, cutting off at about ¾ stroke by lap of the valve. A good point in the portable engine's carrying gear is that the wheels, after the style of fire-engine wheels now so considerably in use, are made with cast-iron hubs and wrought-iron arms cast in; these arms, however, differently from the prevailing practice, are placed in pairs at a considerable distance apart at the hub, converging in the direction of the axis, as they approach the rim, instead of being "staggered" in the usual way. This arrangement gives a stronger wheel for same weight of material than is possible on the older plan.

Chas. W. Ervier & Bro., of Philadelphia, exhibit a horizontal engine, 18 in. x 36 in. cylinder, having at least one novel feature—the form of bed or frame. Novelty, however, is, I think, all that can be claimed for it, and engineers, I am persuaded, will not see in it much to commend. It may be described as a very broad, flat plate of metal, out of which rise at the appropriate places hollow box-projections to support the cylinder and guides, and a long, curved, hollow, horn-like projection, at the extremity of which is placed the main bearing.

William Cramp & Sons exhibit a single-cylinder, condensing propeller engine of the vertical inverted type, with cylinder 20 x 22 in., designed for a tug-boat 85 feet long, 17-foot beam, and 8-foot hold; it is rated at 135 H.P. They also exhibit a compound engine for the same purpose and of the same general design, having cylinders 16 and 28 x 24 in. stroke, intended for a tug-boat 100 feet long, 20-foot beam, and 10-foot hold. The single engine has an expansion gear with the usual gridiron valve on the back of the main slide, the throw of the former being graduated by means of a radius line, while the main valve is operated by the customary Stephenson link motion. The compound engine has the slide valve only, and is without expansion gear other than that which is given by the link motion. There is something anomalous in the placing of expansion gear upon a single-cylinder engine, and exhibiting at its side a compound engine, which form of machine is certainly now considered most favorable to the expansive use of steam, with nothing better than the link motion and slide valve to effect it. The general design and arrangement of parts in these engines is, however, most admirable. The surface condensers form a principal part of the bed-plate, and the cylinders are supported upon a cast-iron exhaust pipe and a bracket nearly uniform with it, on the one side, and two columns rising from near one of the bearings of the main shaft on the other. On the top of the condenser is formed a fulcrum, upon which vibrates a double beam or lever, the inner ends linked to the cross-head of the engine, and the outer ends to another cross-head, from which the air, circulating, and feed pumps are worked. The compound engine has a steam-starting engine. They are more than ordinarily compact, and were designed with reference to accessibility and distribution of material, while the castings are exceedingly fine specimens of workmanship, as indeed the machines are as a whole.

J. D. Lynde, of Philadelphia, exhibits a small, double, horizontal engine with some novel features; the piston rod guides are hollow cylinders bolted to the bed-plate, of sufficient diameter to clear the connecting rod when at its greatest angle with the axis of the steam-cylinder. This has the merit of cheapness, and of being easy of alignment with the axis of the steam cylinder; but, like very many of the novel variations in arrangement of parts of the steam engine, it has demerits which quite overbalance them. In this case its particular ill feature is, that the part in this machine corresponding to what in engines generally goes under the name of crosshead is rendered inaccessible for adjustment, or practically so. The arrangement of the governor in this engine is such that, instead of merely throttling the steam on its way to both cylinders, as is usually the case with plain slide-valve engines, it is made by a peculiar arrangement of parts to exclude the steam entirely from one cylinder before a reduction of the supply to the other commences. The inventor reasons that in this way he saves steam—a proposition, however, which he will find it very difficult to establish; indeed, it is more probable that a greater weight of steam will be required for any reduced load with the moving parts of one engine driven at the expense of steam admitted to the other. The fly-wheel in these engines presents a fair specimen of proportion in such work.

Jacob Naylor, of the People's Works, presents a horizontal engine 18" x 36" cylinder, two smaller ones of same design, and a compound, jet-condensing engine, having 8" and 15" x 18" cylinders. They all have the ordinary slide valve, without expansion gear, except by the lap of the valve, and the valves are all balanced by excluding the steam pressure from a portion of the area of the back with the usual ring. This exhibitor gives us another example of the tendency of manufacturers to adopt the compound form of engine because, perhaps, of its somewhat recent popularity, while they ignore the most vital principles which alone render the compounding desirable or advisable. A compound engine having admission gear such as to preclude the possibility of cutting off the steam until after about two thirds of the stroke is accomplished, is an engineering absurdity.

As specimens of general design and proportion of parts, these engines are, however, most excellent, while the workmanship and finish throughout is all that could be desired; and with some good form of expansion gear their compound condensing engine would be a most commendable machine, as their non-condensing specimens certainly are.

R. C. Moorhouse & Co. exhibit a small non-condensing engine, with the view, it would seem, more to bring to public notice the expansion device attached to it than as a specimen of workmanship, for as such it is rough and crude to a degree not often seen in these days. The expansion gear alluded to is the invention of Mr. Hugo Bilgram, and is certainly an ingenious piece of mechanism, as well as simple and practicable. The slide-valve, actuated by an eccentric through the intervention of a rocking-arm, has its ports passing through it, and upon its back a single block is made to slide by an additional eccentric through the intervention of a second vibrating arm, whose centre of vibration is attached to the first vibrating arm. By a change in position of this centre, not only the amount of travel given the block (which alone is obtainable with customary forms of this kind of cut-off), but also the time of movement of it with reference to that of the main valve, is varied. The governor is of such construction that the work of varying the position of the cut-off gear is done by the engine, so that the whole arrangement constitutes a sensitive and effective automatic slide-valve cut-off; and Mr. Bilgram is to be commiserated in not having his ingenious ideas more creditably developed and presented than in the engine and model shown. This inventor is to be commended for the pains he has taken to provide, by model in section and by diagrams, the means of an easy comprehension of his plans, while so many of his more pretentious competitors make not the slightest provision for an examination or investigation of the internal parts of their engines and valve gear.

J. T. H.

ENGLISH PRINTING MACHINERY AT THE CENTENNIAL.

AMONG the exhibits of English Machinery is the Walter newspaper printing press, from London, which is shown in practical operation, being employed daily for printing the New-York *Times;* from which latter journal we derive the following:

At the end of the United States' long line of printing presses stands a broken down, dilapidated piece of machinery, whose only present outward glory consists in a brass plate, which is far from being polished to too high a lustre. Let every visitor who approaches this relic of the past brush up his history and polish his bump of veneration, for it is before the printing press at which honest old Benjamin Franklin toiled and sweated 148 years ago that he stands. Speaking of one of the incidents of Franklin's London life in 1768, this said brass plate records: "The Dr. at this time visited the printing office of Mr. Watts, of Wild street, Lincoln's Inn Fields, and, going up to this particular press, thus addressed the men who were working at it. 'Come, my friends, we will drink together. It is now forty years since I worked like you at this press as a journeyman printer.' The Dr. then sent for a gallon of porter, and he drank with them, 'Success to Printing.'"

Let us take a walk to the other end of what, for convenience sake, I will call "Printing-press Row," and we have jumped over a century and a half. At all events, we have stepped from the days of Benjamin Franklin, printer, to the days of John Walter, printer, and are standing side by side with a piece of mechanism that only does not rival our own mechanism in that it is not human.

To make this description intelligible, I think I can not do better than accompany, figuratively speaking, a sheet of paper from the time it starts from the parent roll into the press till the moment when, after an intensely hurried journey, it lies on the distributing table ready to convey the news of the day to whomsoever may come along.

The rolls of paper weigh from nine hundred to a thousand pounds, are about five and a half miles long, and will run off into about six thousand five hundred copies of the New-York *Times.* The width of the roll is thirty-six inches, and the length of each copy of the paper, when cut off, is forty-seven and three quarter inches. From this big roll the paper passes round two cylinders, one about two inches above the other. These cylinders are blanketed, are hollow, are filled with water and steam, and are perforated with thousands of minute holes. Each cylinder is covered with three layers of fine woollen blanket, so that the moisture escaping through the perforations may be equally distributed all over the outer surface of the blanket. The paper, on its way through the press, passes under one and over the other of these blanketed cylinders, and is evenly dampened on both surfaces, to take the ink from the printing cylinders. The paper is drawn from the roll, by two plain nipping rollers, which carry them on to supply the printing cylinder; and all work together with the exactitude of the most delicate clock-work—a necessity rendered still more imperative when running at a high rate of speed.

At the top of the press is the stereotyped cylinder from which the inside of the paper is printed. Some eighteen inches below, and standing away from the centre of this stereotyped cylinder, is an ink reservoir extending across the press and about nine inches deep; a roller, about five inches in diameter, revolves slowly in this reservoir, and, as it revolves, a knife scrapes off all the surplus ink from its entire length, allowing just so much ink to remain on the roller as, when it has passed over two other rollers and two cylinders, shall become so perfectly and evenly distributed that when the ink reaches the last roller—the one that inks the stereotyped printing cylinder—no one letter shall have more or less ink than another, while none too little or none too much is distributed over the entire stereotype.

Under the stereotyped cylinder is the impression cylinder, against which it prints; below this first impression cylinder is the second impression cylinder, and immediately below that the stereotyped cylinder, from which the outside of the paper is printed against the second impression cylinder. The sheet of paper, on leaving the two nipping rollers, spoken of above, passes between the upper stereotyped cylinder and the upper impression cylinder, receiving the impression of the inside of the paper as it passes. Then it passes down and between the upper impression cylinder and the lower impression cylinder, and then between the lower impression cylinder and the lower stereotyped cylinder, all four cylinders being placed one above another, the two impression cylinders being in the middle. The lower stereotyped cylinder is inked in precisely the same way as the upper one.

After receiving its last impression, the sheet of paper passes through two cylinders of like diameter, the one immediately above the other. As the sheet passes one, drawn by tapes, it is so arranged that when a divisional line between each successive printed copy passes the central line between the two cylinders, a knife, with a serrated edge, is thrust downward momentarily from the upper cylinder into a corresponding groove in the lower cylinder. The tapes lead down to the flyer, which, working backward and forward, automatically delivers the papers alternately on the two tables—one behind and one in front—and this, with ease, at the speed of from 15,000 to 17,000 copies of the paper per hour.

I have described the Walter Press of to day, and what it can do. I am, fortunately, enabled to tell just what its great forerunner and ancestor could do—the first printing press run by steam, and which was erected in the London *Times* office, by the father of him who is the present proprietor of that world-famous journal and the inventor of the Walter Press. The *Times* was first printed by steam power on the 28th of November, 1814, and the issue of the ensuing day, the 29th, contains the following self-congratulatory comment on so auspicious an event: "Our journal of this day," says the *Times*, "presents to the public the practical result of the greatest improvement connected with printing since the discovery of the art itself. The reader now holds in his hand one of the many thousand impressions of the *Times* newspaper which were taken off last night by a mechanical apparatus. That the magnitude of the invention may be justly appreciated by its effects, we shall inform the public that after the letters are placed by the compositors, and inclosed in what is called a form, little more remains for man to do than to attend and watch this unconscious agent in its operations. The machine is then merely supplied with paper; itself places the form, inks it, adjusts the paper to the form newly inked, stamps the sheet, and gives it to the hands of the attendant, at the same time withdrawing the form for a fresh coat of ink, which itself again distributes, to meet the ensuing sheet, now advancing for impression; *and the whole of these complicated acts is performed with such a velocity and simultaneousness of movement that no less than* 1100 *sheets are impressed in one hour.*" Now, to our advanced ideas, there is something absolutely refreshing in the innocent gush of this statement, "No less than 1100 sheets are impressed in one hour." *Mirabile dictu!* And the Walter press of to-day can run off seventeen thousand copies an hour, and printed on both sides too. None of the one-side impressions of fifty-eight years ago! The simple summary of the result of progress, then, is in the ratio of 34,000 to 1100 impressions in one hour. This is not bad work for one man's lifetime, and is in itself a monument to the energy, enterprise, and liberality of the inventor of the Walter press.

NEW-YORK ACADEMY OF SCIENCES.

THE Geological Section of the New-York Academy of Sciences met at 64 Madison ave., on Monday evening, May 15, President Newberry in the chair. Mr. J. C. Russell, of the School of Mines, who accompanied an expedition to New-Zealand to observe the transit of Venus, read a very interesting paper on the Ancient Glaciers of New-Zealand. Mr. R. described the scenery of that distant island as extremely sublime and beautiful. Its lofty mountains well deserve the name of the Southern Alps; many of the peaks are high and precipitous, Mount Cooke being 13,200 feet in elevation. The glaciers are scarcely, if at all, inferior to those of Switzerland, one of them, which he described, being 18 miles long and 2 miles wide, and exhibiting the interesting phenomenon of receiving into it a tributary stream, formed like itself of solid ice.

Mr. Alexis A. Julien gave a graphic description of a "Search for Flint Implements in the Valley of the Somme," and exhibited a number of the flints found there. The number that has been taken from single gravel beds is very large. There, as elsewhere, fraud is practised, and the manufacture of artificial antiquities is quite profitable, and amateur collectors require to be continually on the guard against such imposition.

Mr. C. B. Chamberlain exhibited specimens of graphic granite from 57th street, also Augite and Oligoclase from New-York, Fern-like Galena from Wisconsin, and Coxcomb Pyrites and Marcasite from the same State.

FRENCH ACADEMY OF SCIENCES.

APRIL.

The Electric Apparatus of the Electric Eel.—M. Rouget concludes that the nervous layers formed by the terminal ganglion are the sole elements constituting the electric organ of the *gymnotus*, in which the transformation of a tensile into an active force may be accomplished; or, in other words, where the change from a neutral into an electrical state may occur.

Daubreite, a new Mineral.—This is an earthy mass of a whitish-yellow color, fibrous in texture, and found in pearly opaque crystalline plates. Its hardness does not exceed 2 to 2.5; density, 6.4 to 6.5. Analysis shows sesquioxide of bismuth, 89.6; chlorine, 7.5; water, 3.84; sesquioxide of iron, 0.72. The discoverer, M. Domeyko, concludes that the mineral is an oxychloride of bismuth, and completes the following series of three oxychlorides: $(Bc^3 O^3)\ Bc^3 Cl^3$. The name is given in honor of M. Daubrée.

On the Pyrogenous Decomposition of Nitrate of Ammonia, and on the Volatility of the Ammoniacal Salts. By M. Berthelot.—Nitrate of ammonia melts at about 305.6° Fahr., a temperature of which the water pre-existing or formed by the decomposition of the salt does not allow of accurate determination. It is only above 410° that decomposition occurs sufficient to furnish in a few minutes an appreciable volume of gas. This decomposition becomes more and more active as the temperature of the melted salt is elevated by the application of heat, without, however, the temperature becoming fixed at any point between 392° and 572°. If additional heat is supplied, the reaction becomes explosive.

The quantity of protoxide of nitrogen collected, however, remains always inferior to that theoretically indicated, because of the apparent or real volatility of the nitrate of ammonia. The dissipation is very considerable, even if the operation be conducted at the lowest temperature and in such manner as to hinder as much as possible the sublimed portions in the cold parts of the apparatus from returning to the heated parts at the same time as the water condenses. Nitrate of ammonia may otherwise be sublimed without notably destroying it, by previously placing the melted salt in a capsule by the aid of a leaf of bibulous paper surmounted by a paste-board cylinder filled with large pieces of glass. Melting is effected in the sand-bath, the temperature not being allowed to exceed 374° to 414°. A very considerable portion of the salt then sublimes in fine brilliant crystals, which attach themselves to the sides of the capsule and to the lower surface of the paper. A portion traverses the latter and condenses in the form of a fine smoke, very difficult to collect; the identity of which, however, with nitrate of ammonia the author has fully determined by analysis. The temperature of the paper thus traversed by the vapor may be elevated even to 266° without the paper becoming notably altered.

M. Berthelot attaches considerable importance to this experiment, since it demonstrates that nitrate of ammonia may be volatilized in nature without being previously decomposed into ammonia and gaseous nitric acid $(N O^6 H + N H^3)$, which would recombine their dissociated mixture, possessing all the energy of the isolated components. In fact, it can not otherwise be understood how the vapor of monohydrated nitric acid may be found in contact with paper at a temperature which is necessarily comprised between 266° and 376°, without oxidizing and instantly destroying it.

On the Vegetation of Plants deprived of Chlorophyll. By M. Boussingault.—The globules of yeast, the *Mucedinæ*, in a word the parasites, attain a complete development similar to that of the *Helianthus*, a chlorophyll plant, in an artificial medium containing nothing but definite and crystallized chemical compounds. The difference, however, is great. The *Helianthus* takes all its carbonated elements in the exterior world; the carbon in the atmosphere; hydrogen and oxygen in water. The parasites, on the other hand, in the above case, took carbon in substances which, although of definite chemical construction and even crystallized, are derived from vegetable organisms. For sugar and tartaric acid are indubitably shut up in the chlorophyll plant under the influence of solar radiation. Their carbon, and that also derived from the refuse and detritus of animals and vegetables on which the fungi thrive, are derived from the carbonic acid of the atmosphere. The existence of the parasites in an obscure place, where their cellules form immediate principles, similar to those produced in bright daylight by plants of green protoplasm, is far from being an exception to, as has been affirmed, but is rather a confirmation of, the necessary relation of light and vegetation. If the solar radiation should cease, therefore, not only would the chlorophyll plants, but also those deprived of chlorophyll, disappear from the earth.

Observations on the foregoing. By M. Pasteur.—If the solar radiation should cease, life hereafter would be impossible for large vegetation, but it might continue in certain inferior organisms. Through the methods which chemistry owes to M. Berthelot, carbon and watery vapor, set at work by heat and by the reactions of the laboratory, may give rise to many substances capable of serving as carbonated aliment for inferior plants. Moreover, it may be conceived that under the influence of the latter all the carbon existing at the surface of the earth, or in the interior, might pass into complex organic matters, and that ulteriorly it would return to the atmosphere under the form of carbonic acid through the actions of oxidation and fermentation. It would be only when this termination was reached that all manifestation of life would be impossible without the aid of solar radiation.

On Gastrotomy. By M. Labbe. [This has reference to a remarkable surgical operation lately performed in Paris, consisting of the removal of a silver fork from the stomach. The patient, two years previously, attempted the sword-swallowing trick practised by jugglers, by introducing the fork into his œsophagus and holding the tines in his teeth. Accidentally, while the fork was in this position, his hold slipped and the object descended. Attempts to extract it with the forceps brought on a severe attack of coughing, which lodged the fork in the stomach. The patient did not experience uneasiness until some two weeks had elapsed, when the pain became severe. Processes of digestion continued as usual with great suffering until the recent removal of the obstruction, by cutting into the stomach.—EDS.]—The success of this operation was due to the combination of several conditions: 1. The operation itself, based on the most exact knowledge of the viscera divided; 2, to the precaution of fixing the stomach to the abdominal coverings before opening it; 3, to the employment of an extremely thick layer of collodion, which rendered the abdominal surface and the digestive tube itself immovable, while applying to them at the same time a very strong compression. Through the latter the type of respiration was modified clearly from diaphragmatic to that of superior costal.

On the Exchanges of Ammonia between Natural Waters and the Atmosphere. By M. Schloesing.—The vapor of water and the ammonia of the air, after having had (according to all probability) a common origin, the sea, are precipitated together, but in different ratio, according as the air is cooled, to 32° Fahr. Below this point the association is ruptured. Water alone continues to be precipitated, but the ammonia remains in the atmosphere, so that the air is never entirely free from it. This resistance of ammonia to condensation, the author considers explains the richness therein of certain mists observed in Germany by M. Boussingault, which deposited water containing .6 grains of ammonia per quart of water.

ACTION OF LIGHT ON SELENIUM.

DR. C. WILLIAM SIEMENS recently gave a lecture to the members of the Royal Institution on the above subject.

Commencing with a general reference to light as a natural force, he showed how little the potential action of light made itself evident to our senses, as with the disappearance of the light its effects seemed entirely to vanish; he then showed a temporary effect of light by its action on phosphorescent salts, which continue to glow for a long time after the source of light is removed, and drew attention to the permanent effect produced by the decomposition of the salts of silver in photography. He next referred to the radiometer, Mr. Crooke's little machine for illustrating light effects, which he brought forward for the purpose of showing the motive power of light, and closed his introduction by a reference to some experiments which he had made on a fungus that lives in the dark, and which, on analysis, gave no evidence of containing carbon, thus helping to favor the hypothesis *that it is not heat, but the ray of light which breaks up carbonic acid in the leaves of plants in order to separate the carbon.*

Selenium was discovered in 1817 by Berzelius, as a by product from the distillation of iron pyrites. It is fusible, combustible, and similar to sulphur, phosphorus, and tellurium. If melted (at 217° C.) and cooled rapidly, it presents a brown amorphous mass of conchoidal fracture, and is a non-conductor of electricity; if heated only to 100° C., and retained for some time at this temperature, it becomes crystalline, and is a slight conductor of electricity, the conductivity increasing with battery power, and varying according to the direction of the current, as lately observed by Prof. Adams.

It was on the 12th of February, 1873, that the Society of Telegraph Engineers received a communication from Mr. Willoughby Smith, one of its members, of an observation made first by Mr. May, a telegraph clerk at Valentia, namely, that a stick of crystalline selenium offered considerably less resistance to a battery current when exposed to the light than when kept in the dark; this was corroborated by the Earl of Rosse, who clearly proved the action to be due *solely* to light, and who also showed the effects of the light of different portions of the spectrum, and afterwards by Lieut. Sale, and conjointly by Messrs. H. N. Draper, F.C.S., and R. J. Moss, F.C.S.

About twelve months ago the matter was again taken up by two independent observers, Prof. Adams in this country and Dr. Werner Siemens in Germany, and it was to the results obtained by the latter, and which have been communicated to the Academy of Sciences of Berlin, that the lecturer's remarks were chiefly confined.

The sensitive selenium plates made by Dr. Werner Siemens, with which experiments were made, are formed of two spirals of platinum wire, laid upon a plate of mica, in such a manner that the two wires run parallel without touching; upon the plate a drop of molten selenium is allowed to fall, and before solidifying, another plate of mica is pressed down; the two protruding ends of wire serve to insert the selenium element in a galvanic circuit. Amorphous selenium when thus tested produces no deflection of the galvanometer, either in light or darkness. If, however, a selenium disc which has been kept for some time at 100° C., and then cooled is inserted, a slight deflection of the galvanometer takes place when it is under the influence of light, but none in darkness. If now a selenium disc which has been kept for several hours at a temperature of 210° C., a point below that of the fusion of selenium, and which has been gradually cooled is substituted for the other, a considerable deflection under the influence of light will be observed, whilst a hardly perceptible deflection takes place in the dark.

It was also explained, as the result of an experiment, that amorphous selenium did not conduct up to 80° C.; from this temperature to 210° C., its conductivity gradually increased, after which the conductivity again diminished; in cooling it followed the same law, but in a different ratio. The modification prepared by heating to 100° C. only is Dr. Werner Siemens' 1st, or electrolyte modification, whilst the other, prepared by heating to 210° C., is his 2d, or metallic modification. In the 1st, the conductivity *increases* with rise of temperature; in the 2d it *decreases*; the 2d is a much better conductor, but is less stable, and its conductivity increases with the intensity of the light, as shown from the following table, in which is given the effects of different intensities of light on selenium (Modification II.) obtained by Dr. Obach in Mr. Siemens' laboratory at Woolwich on the 14th February, 1876:—

Selenium in	Relative Conductivities.		Resistance in Ohms.
	Deflections.	Ratio.	
1. Dark	32	1.	10,070,000
2. Diffused daylight	110	3.4	2,930,000
3. Lamplight	180	5.6	1,790,000
4. Sunlight	470	14.7	680,000

From these experimental results an extension of Helmholtz's theory is derived, namely, that the conductivity of metals varies inversely as their total heat (Helmholtz having only the sensible heat in view), and the influence of light upon selenium is explained by a change in its molecular condition near the surface, from the first or electrolyte into the second or metallic modification, or, in other words, by a liberation of specific heat upon the illuminated surface of the crystalline selenium.

In testing the sensitive selenium plate in the different parts of the spectrum, it was shown that the actinic ray exercised no sensible effect, that the effect increases as we gradually approach the dark red, and that beyond that point the effect again decreases, reaching almost zero in the heat rays; the value of the material then for purposes of photometry is apparent.

Dr. Werner Siemens has constructed a selenium photometer, in which the selenium is prepared so as not to be affected by the changes to which that substance is liable, and which consists of a single sensitive plate mounted upon a vertical axis, upon which it can be turned through a certain angular distance limited by stops. When touching the one stop the selenium stands opposite the normal candle, and when touching the other opposite the light to be measured, the distance upon the former being changed upon a scale until no effect upon the needle of a galvanometer is produced in turning the sensitive plate in rapid succession from the one stop to the other.

The lecture was concluded by the exhibition of a selenium eye, which Mr. Siemens had prepared to illustrate the extraordinary sensitiveness of the selenium preparations. It consists of a hollow ball with two circular openings opposite each other, the one being furnished with a lens 1½ inches in diameter, and the other with an adjustable stopper carrying a sensitive plate, which is connected by wires to a galvanometer and one Daniell's cell. The lens is covered by two slides representing eyelids, the ball itself being the body of the eye, and the sensitive plate occupying the place of the retina. Having placed a white illuminated screen in front of the artificial eye, on opening the eyelids a strong deflection of the galvanometer was observed, a black screen giving hardly any deflection, a blue one a greater, a red a much greater, but still short of that produced by the reflected white light. The eye was thus sensitive to light and color, and as stated, it would not be difficult to arrange a contact and electro-magnet in connection with the galvanometer, so that intense light would cause the automatic closing of the eyelids. The artificial eye is subject to fatigue, and the lecturer considered that this experiment might be suggestive to physiologists as regards the natural conjoint action of the retina and the brain.—*Nature.*

ANCIENT PERU.

MR. ALEXANDER AGASSIZ gave the annual lecture before the Harvard Natural History Society in Boylston Hall, Cambridge, recently. The subject was "The Ancient Civilization of Peru," and was treated in a very interesting manner. A large number of relics showing the manners and costumes of the ancient Incas were exhibited. Among them were mummies, specimens of pottery clothing, and numerous engravings. In speaking of the dwellings of the Peruvians, Mr. Agassiz said that in many cases they resembled those of Indians. They manufactured great quantities of articles of pottery, and in a small hut could be found a great many pieces. They were, in fact, the furniture of the establishment. The remains of buildings of a former period were, in point of architecture, Cyclopean; that is, they were built of the stones and boulders as they were found in the fields, joined together and held in position by copper rods containing an alloy of gold, which, unfortunately, the first discoverers melted to secure the gold. Commercial intercourse between the coast and the interior was had by means of llamas, on the backs of which the dwellers in the interior conveyed to the coast the wool of the llamas. The llama was, if possible, more stubborn than the mule. If the animal was not loaded to its liking it would lie down and remain, and no amount of persuasion or force would induce him to go on until the load was diminished. When a native started for the coast with his flock of llamas, it was not uncommon to see them all lie down after going a short distance. If one stopped the entire flock followed suit. The llama would bear from 60 to 90 pounds, and would make about 12 miles a day, so that the distance from the interior to the coast, 300 or 400 miles, was not speedily accomplished. There was a kind of railroad connecting the two districts, but, owing to the high tariff, the Peruvians preferred to spend six months in a journey with their llamas rather than pay the freight charges. The mummies exhibited were enclosed in a wrapping made of fibre, and the whole was enclosed in rushes. The arms of the dead were folded across the breast, and the legs forced back upon them, the knees touching the head. When the body was buried all his earthly possessions were buried with him, and a basket of corn was also supplied that he should not hunger on his way to the better land.

OUR FOREIGN IRON TRADE.

THROUGH the courtesy of Dr. Edward Young, Chief of the Bureau of Statistics, we have received such information that we are enabled to present the table appended hereto of the total value of the imports and exports of iron and steel and manufactures thereof for each of the calendar years ended December 31, 1871, 1872, 1873, 1874 and 1875.

Calendar Years.	Imports.	Domestic Exports.
1871	$47,919,926	$15,206,179
1872	61,734,227	14,360,617
1873	45,764,670	16,687,754
1874	24,600,720	20,460,732
1875	15,273,315	20,417,635

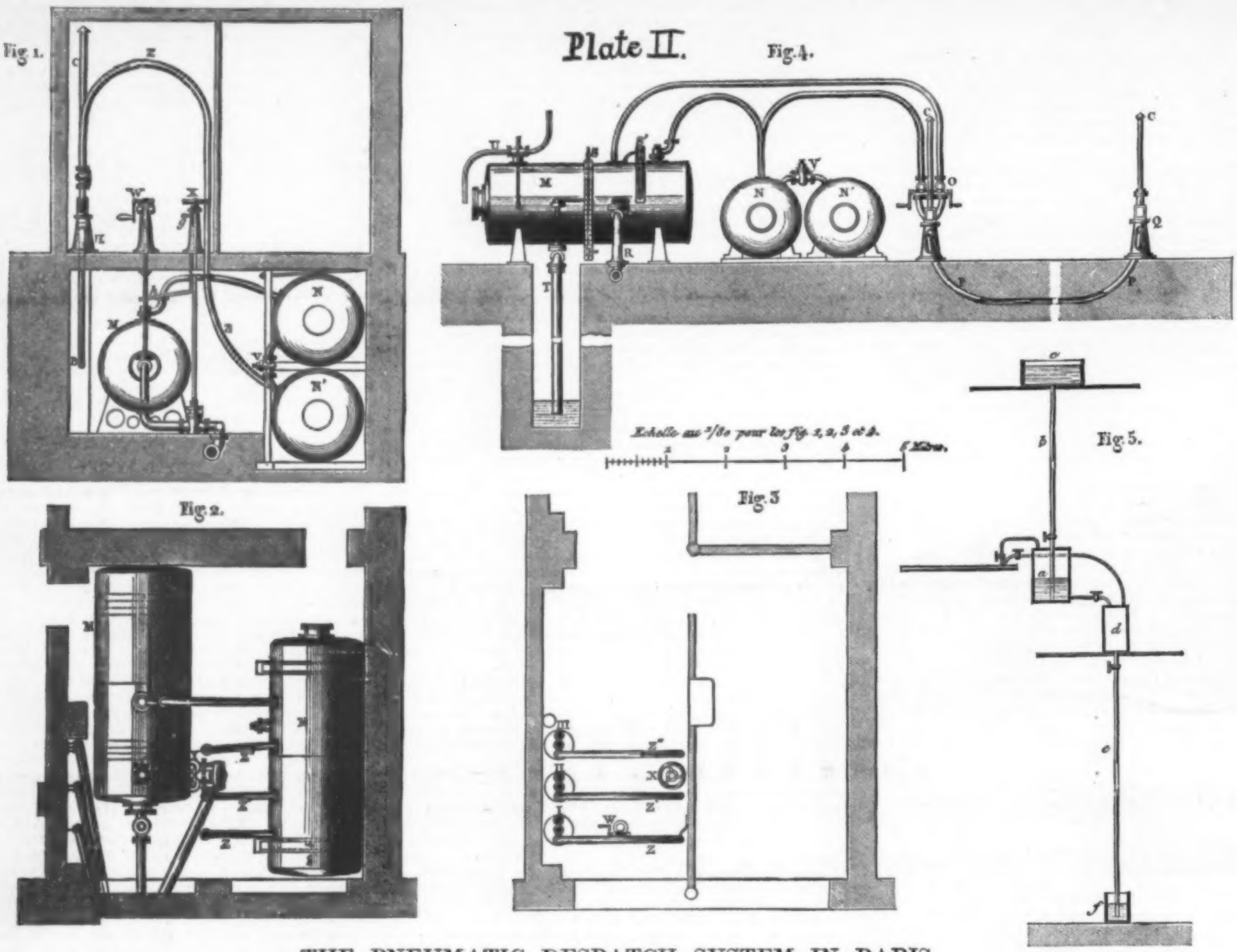
The above exports include iron and steel and such manufactures thereof as car-wheels, stoves, machinery, steam-engines, cutlery, fire-arms, agricultural implements, scales, sewing-machines, fire-engines, etc. While the exports of 1875 exhibit a slight falling off as compared with 1874, their value far exceeds that of the iron and steel imports for 1875. In 1874 the excess of imports over exports was $4,139,988; in 1875 the excess of exports over imports was $5,144,320, which is certainly a very gratifying exhibit to American iron manufacturers.

The leading articles imported in 1875, the weight of which can be ascertained from Dr. Young's tables, are as follows: pig iron, 66,457 net tons; castings, 23 tons; bar iron, 24,591 tons; boiler iron, 46 tons; band, hoop, and scroll iron, 228 tons; iron rails, 1942 tons; steel rails, 16,316 tons; sheet iron, 3616 tons; old and scrap iron, 25,856 tons; anchors, cables, and chains, 2004 tons. The value of the pig iron, bar iron, iron rails, steel rails, and sheet iron imported in 1875 was $5,365,608, being more than one-third of the total value of the imports of iron and steel and their manufactures.—*Bulletin Amer. Assoc.*

SMALL-POX SPREAD BY DOGS.

A RURAL sanitary organization in England has applied, through Dr. Mackintosh (*British Medical Journal*), for an order from the magistrates to have all dogs in the district of Bolsover chained until small-pox has disappeared in that locality.

Dr. Mackintosh considers, and very properly we think, that "the disease is spread from house to house more by domestic animals than by anything else." We believe that the more this subject is examined from this point of view, the more the views advanced will be considered correct. It is possible also that the spread of other contagious diseases, such, for instance, as scarlet fever, may be explained in this way when all other recognized reasons have failed.—*Medical Record.*



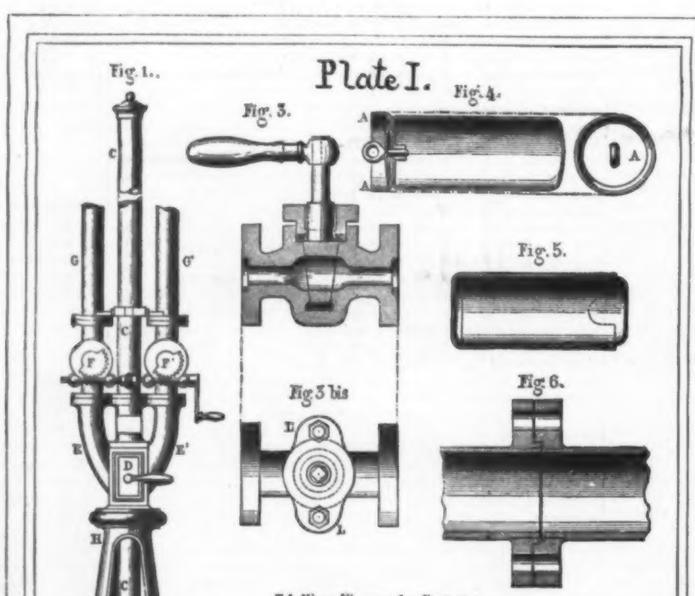
THE PNEUMATIC DESPATCH SYSTEM IN PARIS.

THE PNEUMATIC DESPATCH SYSTEM IN PARIS.

Paris at the present time is traversed by about thirteen miles of tubes, through which messages are transmitted between nearly all the principal localities in the city by pneumatic pressure. Paradoxical as it may appear, the rapidity with which despatches may by this means be sent between short distances exceeds that of the telegraph, when the number of distinct despatches which it is possible to transmit in a given time is taken into consideration. Forty messages of one hundred and fifty signs each per hour is about as rapid work as can ordinarily be accomplished on a single wire, allowance being made for the necessary writing out of the despatches, etc. By the pneumatic tube connecting with the Bourse, stock quotations are forwarded to various parts of the city at the rate of 8000 per hour, it being possible to start twenty trains of boxes containing four hundred written despatches each in that period of time.

The apparatus employed, invented by MM. Mignon and Rouart, is extremely simple, and will be understood from the annexed engravings extracted from the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale.* The tubes are of a uniform diameter of 2.6 inches, and are drawn of wrought iron. The joint which connects the sections is represented in Fig. 6, Plate I., and is rendered tight by a thin sheet of india-rubber placed between the partitions. These connections are placed at distances of about 25 feet apart. The carriages used are of two kinds: those which receive the pneumatic pressure, and so are forced through the tubes; and those which make up the train, which is drawn by the former, and in which the written messages are directly deposited. The first are hollow cylindrical boxes of wood or metal (Fig. 4, Plate I.), and to the rear of each is secured a leather-flanged disk, which packs itself against the interior of the tube when impelled by the blast. The other carriages are of metal, covered with leather, and resemble in shape and form small cigar-cases (Fig. 5, Plate I.). They are about 4 in. less in diameter than the tube, and simply glide along its interior when drawn by the pulling carriages above mentioned. The speed of the train is some 36 miles per hour, under a total pressure in the tube of from 44 to 55 lbs.

The principle of the apparatus, by which air is compressed in rear of the carriages, or a vacuum formed in advance of them, either or both of which means of propulsion can be used at will, is exhibited in Fig. 5, Plate II. *a* is an air-tight reservoir, connected by the pipe *b* with the elevated receptacle *c*. In the latter water enters from the city mains, and, descending with a pressure proportionate to the head, enters *a*, and compresses the air



THE PNEUMATIC DESPATCH SYSTEM IN PARIS.

therein until an equilibrium of pressure ensues. If *a* contain one cubic foot of air, for example and the water enters to fill half its volume, the air then will be under a pressure of two atmospheres, and may be led off by pipes to perform its work. A reverse process produces the vacuum. The water already in *a* is led into the chamber *d*, whence a tube, *e*, descends to a chamber situated more than 32 ft. below. *d* being full of water, and communication being opened through *e* and shut from *a*, it is obvious that a water barometer will be formed and the water descending in *e* will leave nearly, a perfect vacuum in *d*. It remains only to shut the cock in *e* and open connection through the pneumatic tubes when the normal air pressure in rear of the carriages will impel them.

The starting and receiving apparatus, which are identical, and may be placed either vertically or horizontally, are shown in Figs. 1 and 2, Plate I. B is the message tube, terminating in a vertical portion C, on which is an iron box D, having a door which may be hermetically closed. From said box extend branch tubes, EE′, in which are placed valves or cocks, operated by the toothed sectors FF′, and the endless screw and crank shown. The arrangement of these valves is such that when one is opened the other is closed, and *vice versa*, the single crank operating both at once. The train of carriages is dropped through the box D into the tube C, the door is closed, and if compressed air is to be used, the handle is turned so as to admit the pressure, for example from tube E; the other tube, which opens into the atmosphere, is necessarily then closed. If a vacuum is to be employed, the crank is turned so as to reverse the valves, the compressed air being shut off, and that of the atmosphere allowed to enter.

When the carriages reach their destination, they pass the box D, where the compressed air finds an exit, and shoot into the prolongation C. By compressing the air before them they form an air cushion, which checks their momentum without shock, and they rebound. They then may be removed at D, or may be allowed to accumulate in C, which is hinged at I, Fig. 2, so as to be opened when desired for their removal. Electric communication between stations gives warning of the departure of trains, etc.

The air-compressing and vacuum apparatus actually in use is exhibited in plan Figs. 2 and 3, and end and side elevations in Figs. 1 and 4, Plate II. M is the water chamber, and N N (two cylinders being employed for economy of room) are the air or vacuum chambers. O is the transmitting apparatus, P the tube, and Q the receiver. R is the water-pipe leading from the city mains, the water from which compresses air in M, which air is then drawn off for use into the cylinders N N. S is a water-gauge to show the water level within. The chamber M may also be used as a vacuum

chamber by allowing the water to escape by the pipe T, the vacuum being likewise produced in chambers N. Water can be removed without causing a vacuum by opening the air-cock U. The form of cock used in the entire apparatus is shown in Fig. 3, Plate I. Its principal feature is an india-rubber packing at K, which is tightly forced down to prevent leakage around the key.

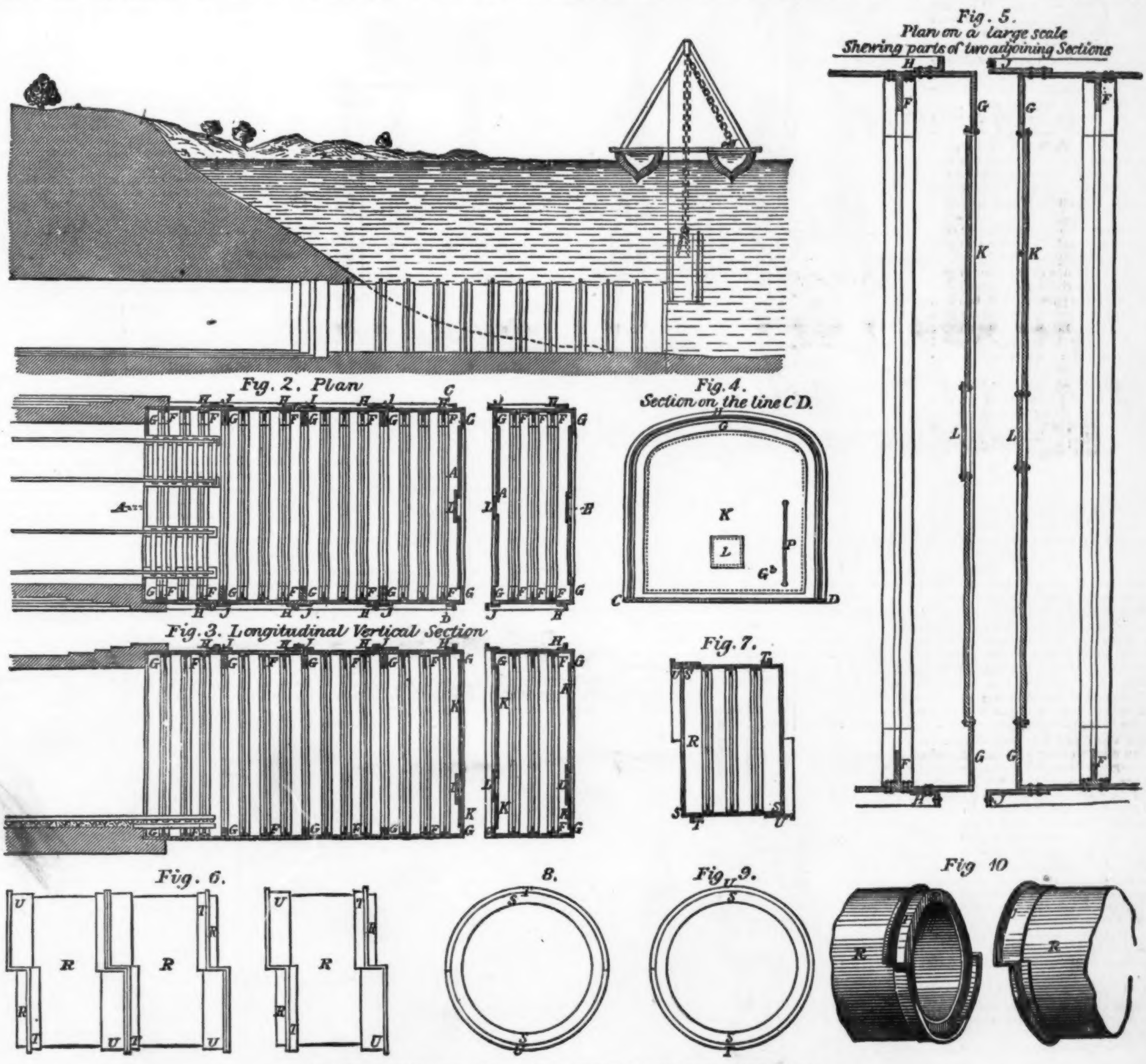
As regards cost of water for operating the system in Paris, for compression, the sum for each despatch averages about half a mill; vacuum, however, being employed without additional cost, a reduction of one half this figure follows, so that the water costs one cent for every forty messages.

RAYNOR'S PLAN FOR SUBMARINE TUNNEL.

THE scheme for submarine communication with the Continent by means of a tunnel under the Channel was recently advanced a stage by the completion of certain soundings in the "silver streak," and stratigraphical observations on the geological structure of its basin, carried on on both sides of the Channel. It is understood that the latter were favorable, that the indications observed made it probable that a bed of hard chalk suitable for the construction of the proposed work extended continuously from shore to shore at a convenient depth below the sea bottom. It must, however, be remembered that many skilful geologists, numbering among them men specially acquainted with the stratum which it is proposed to penetrate, have expressed fears, deduced from the conditions under which the Channel must have been originally formed, that faults or rents may exist in the chalk that may seriously embarrass the engineers, if not ruin the whole scheme. There also occur in this formation cavities technically called potholes, which extend, in the form of funnels filled with sand and other *débris*, to a considerable depth. The effect of either of these impediments occurring in the course of the work would be very serious. A similar fault in the case of the Thames Tunnel was overcome with difficulty. It is doubtful, also, whether the information to be gained by the preliminary horizontal bore is to be altogether trusted.

There are, however, other schemes in nowise dependent on the character of the underlying rocks, but are bold, perhaps too bold, attempts still farther to extend the use of a metal which has of late been employed to supersede in a greater or less degree all other constructive materials. One of these schemes was propounded some considerable time ago by Mr. Barlow, the engineer of the Thames Subway, and succinctly described in our columns. It consisted of a steel tube strengthened by a casing of bricks and woodwork, and was to be either sunk along the bottom or suspended out of reach of injury from passing vessels. Another is that brought before the Society of Engineers the other night by Mr. Perry F. Nursey, C.E., and the invention of Mr. P. J. Bishop, although the details had been worked out by Mr. Nursey himself. This system consists of two distinct tubes of cast iron, each carrying a line of rails laid on the bed of the Channel between Dover and Cape Grisnez, a distance of 21¾ miles, at an estimated cost of one million sterling per mile. The tube, which is elliptical in section, would be 4 inches thick, cast in 5-feet lengths, bolted together by internal flanges, lined inside with brickwork laid in cement, and that cased again with ⅝ inch boiler-plate. The outer dimensions, 17 feet 8 inches diameter of the major axis, and 14 feet 8 inches the minor axis; the inner diameters being 15 feet and 12 feet respectively. The tube would be sunk in 25-feet lengths, an ingenious water-tight bulkhead being fixed at each end, with a central guide to bring them in juxtaposition for bolting when they are sunk. The bulkheads are removable from the inside, and would be sent on shore in a trolly as the tube progressed, to be used for a fresh section. The operation of sinking would be carried on from a floating pontoon 400 feet long by 100 feet wide, with a central opening 100 feet by 25 feet, surrounded by staging for lowering each section. A third is that the title of which heads this article, and which is the invention of Mr. George Raynor, of Hackney. Shortly described, it is an iron tunnel put together in lengths or sections which, after being lowered into the sea-bed, are bolted together from the inside, the water being excluded, and section after section added until the opposite shore is reached. These tubular tunnels may of course be used for the passage of rivers as well as seas.

The illustrations show Raynor's Tunnel in course of construction and in various forms of section. The description of iron used is, by preference, boiler plate, riveted in the same way as boilers are, and strengthened internally by flanges or frames as required. Each section is provided at its ends with an internal flange, G, formed of the same substance as the body of the tunnel and turned inwards. These flanges, when ultimately riveted together, constitute the permanent connection between the sections, the end next the shore having riveted to it a short length of slightly larger tube with a modified flange. Each section, before being lowered into the water, is fitted to those with which it is to be placed in immediate contact, and the holes for the rivets prepared. Bulkheads or diaphragms, K, of similar boiler plate, strengthened where necessary, and slightly larger than the opening left by the internal flanges, G, to which they are to be attached, are added on the external section of the flange, and secured by screws, each diaphragm having a man-hole closed by a shutter, and attached to the end next the shore. When a section is fixed the shutters are removed. The approach to the subaqueous portion of the tunnel may be made by means of a coffer-dam till the first section of the iron construction is laid, this section having various devices applied to it in order to render it completely water-tight. Having removed the coffer-dams and the whole course of the intended tunnel being levelled, should the inequalities of the bottom render it necessary, the next section, having both ends closed, is brought over the spot in a barge, built after the model of the *Castalia*, with sufficient distance between the twin vessels to admit of a section of tube being lowered between them from a platform connecting the two. A diver now descends, carrying with him a stout tapering iron rod, which he screws into a pole prepared for its reception. The upper part of the rod is made fast to the overhead gear, to which also is attached the pulley apparatus for lowering the sections. A similar guide rod is attached to the other side of the section, which is then slowly lowered until it slides over the projecting end of the previously fixed section, and the flanges of each are brought into close contact. Divers then proceed to insert screw-bolts through the external flanges, with or without a vulcanite or india-rubber washer, as may be found necessary. The screw-bolts having been tightened, and the joint made sufficiently water-tight, the shutter in the manhole of the first diaphragm is unscrewed and removed, and the next also if the section is free from water, and the workmen entering the section withdraw the plugs which had been inserted in the holes for the rivets in the inner flange, close them with red-hot bolts in the usual manner, the contraction of the iron on cooling bringing the surfaces of the flanges into very close contact, and rendering the joint completely and permanently water-tight. The other diaphragm can now be removed, thus opening up free way to the end of the section. On the work reaching the opposite shore, the final section is to be laid, so as to bring it close up to the brickwork, previously prepared to meet it, and from which the water is excluded by a diaphragm placed a short distance within the end previously to the removal of the coffer-dams used in its construction, and then divers may lay in hydraulic cement the few courses of bricks required to make a sound junction. Should it be necessary to vary the direction of the tunnel in any part of its course under water, or to cause it to rise or descend in order to follow the inclination of the bed, the ends of one or more of the sections can be bent slightly instead of being exactly parallel. If it should be considered advisable to construct the tunnel of any other shape than that just described, a slight modification of the lower part of the sections will be necessary.—*Iron.*

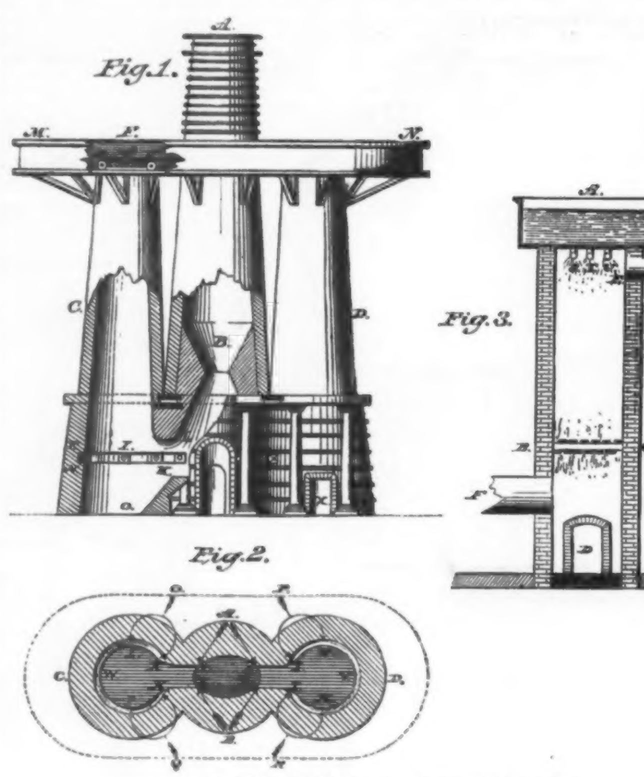


RAYNOR'S PLAN FOR SUBMARINE TUNNEL.

IRON AND STEEL FROM THE ORE.

By W. A. Lyttle, Grove, Hammersmith, Eng.

I reduce the ore to powder, and in order to facilitate such reduction, in some cases, I heat or roast the ore, and plunge it while hot into water, so that it becomes partially disintegrated. I mix the ore-powder with any plastic earthy material, such as clay, mud, peat, or sediment of sewage, adding, in some cases, lime to increase cohesion, and to take up sulphur and silica, and with carbonaceous matter and suitable fluxing materials. The carbonaceous matter, which is also in a state of powder, may be coal, coke, peat, or charcoal, and I prefer to select such matter as is comparatively free from phosphorus. The quantity of carbonaceous matter is such as to suffice for the reduction of the ore, and also to furnish the fuel necessary for its reduction and fusion. The fluxing materials are selected according to the nature of the ore treated, so as to form with its products a fusible slag, and its quantity will depend also on the nature of the iron, and on the quantity of clay employed to agglutinate the mixture. These ingredients are thoroughly mingled together by any known method of pugging, so as to form a cohesive compound like bricks in their moist condition, and the compound may be moulded into bricks, or may be simply extruded in lumps of irregular form and size from the pug-mill. The bricks or lumps of compound may be dried; but this is not necessary when they are to be treated in a furnace such as I will presently describe. Also, when bituminous coal or raw peat is employed as the carbonaceous material, the compound or the lumps thereof may be coked by heat like ordinary coals; but this is also unnecessary.



NEW FURNACE FOR IRON AND STEEL.

By dispensing with the drying or coking of the compound a large economy of time and of heating-power is effected.

The bricks or lumps of compound prepared as above described are charged into a vertical furnace or cupola fed at the top, so that the hot gases rising from the lower part of the furnace serve to dry and coke the upper layers of compound before they reach the hot zone of the furnace below.

The furnace is arranged for the purpose of keeping the fuel out of contact with the material under treatment, the latter being exposed only to the action of the flame or gaseous products of combustion. The central portion A B is the cupola, in which the smelting is effected. On each side of it at C and D is a chamber containing the fuel, made to taper outward toward the base, so that the fuel may descend freely, and constructed of such height that the adhesion of coked fuel to the lower part may be overcome by the weight of the superincumbent mass of fuel. These chambers are provided with covers F at top, which are removed from time to time for charging with fuel, and replaced so as to leave no opening for escape of products of combustion at the top of the chamber. Blasts are directed into the lower part of the fuel-chamber, as indicated by the arrows O P Q R in Fig. 2, and the action of these blasts is distributed uniformly over the mass of fuel at the bottom of the chamber by means of a ring, I, of trough form in section, into which the several tuyeres are led. These blasts may be heated; but I prefer, generally, to employ cold-blasts. The products of combustion from the mass of fuel burning at the bottom of the chamber, finding no escape upward, pass by the passage K L into the cupola A B, and the heat at the base of the cupola may be intensified when required by additional blasts, as indicated by the arrows diverging from A and B, Fig. 2. The bottom of each fuel-chamber of this furnace may be carried down, as a blind, well below the level of the plane of combustion, in which the tuyeres of the blast are placed, and by providing this well with a side door, X, the ash and clinkers may be periodically removed. The bottom of the cupola A B with its hearth, tapping-holes, and other details, is of ordinary construction.

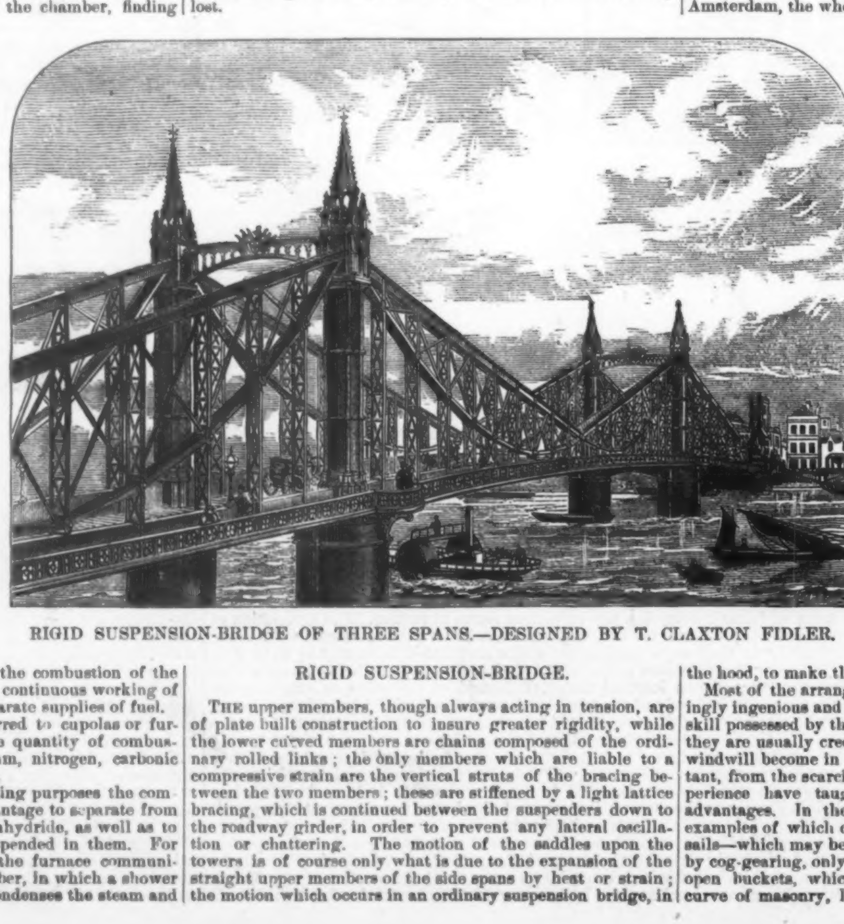
When an ordinary cupola or blast furnace is employed for treating the lumps or bricks of compound which I have described, the fuel and lumps of compound are charged in the usual way in alternate layers when the lumps are compounded with only the quantity of carbonaceous matter necessary for reduction. If, however, they are compounded with sufficient of such matter, not only for reduction, but also for furnishing the fuel necessary for fusion, the layers of fuel may be dispensed with, and in that case the lower part of the furnace is charged, in the first instance, with fuel of an open character, such as coke, the combustion of which serves to get up the heat and to dry the lumps of compound fed above, after which the combustion of the fuel in the lower lumps suffices for the continuous working of the furnace without the addition of separate supplies of fuel.

In the above description I have referred to cupolas or furnaces open at the top, whence a large quantity of combustible gas will escape mixed with steam, nitrogen, carbonic anhydride, and other gaseous products.

When it is desired to utilize for heating purposes the combustible gases so escaping it is of advantage to separate from them the watery vapor and carbonic anhydride, as well as to cleanse them from solid particles suspended in them. For this purpose I make the top mouth of the furnace communicate with the lower part of a tall chamber, in which a shower of water is kept falling. The water condenses the steam and throws down the solid impurities, and as a large portion of these consist of lime in a caustic state a considerable portion of the carbonic anhydride is absorbed by combination with the lime and water to form carbonate of lime. The gaseous products, thus to a large extent purified, are conducted from the upper part of the purifying-chamber to be utilized for heating purposes.

Fig. 3 represents a vertical section of a purifying-chamber suitable for operating as I have described. It consists of a tall chamber surrounded by a cistern, A, from which water issues by nozzles S T V, arranged so as to spread it into a diffused shower. The products of combustion from the furnace enter the chamber by the lower pipe F, and ascend in a direction opposite to that of the descending streams of water, being finally conducted away by the pipe E H K. A grating, B C, is with advantage placed in the chamber to break up and distribute more completely the descending streams, and by making this grating of double bars overlapping each other the gaseous ascending currents are brought into more intimate contact with the descending liquid. The water, with the solid matter carried down by it to the bottom of the chamber, may filter away by a gravel-bed, a door, D, being provided for the removal from time to time of the solid matter that is retained.

When lead is smelted, as above described, the purifying-chamber shown in Fig. 3 is of advantage for throwing down and retaining the lead, "smoke," or oxide which is usually lost.



RIGID SUSPENSION-BRIDGE OF THREE SPANS.—DESIGNED BY T. CLAXTON FIDLER.

RIGID SUSPENSION-BRIDGE.

The upper members, though always acting in tension, are of plate built construction to insure greater rigidity, while the lower curved members are chains composed of the ordinary rolled links; the only members which are liable to a compressive strain are the vertical struts of the bracing between the two members; these are stiffened by a light lattice bracing, which is continued between the suspenders down to the roadway girder, in order to prevent any lateral oscillation or chattering. The motion of the saddles upon the towers is of course only what is due to the expansion of the straight upper members of the side spans by heat or strain; the motion which occurs in an ordinary suspension bridge, in restoring equilibrium between the loaded and unloaded spans, does not here take place.—*Engineering*.

WINDMILLS.

Horizontal windmills are almost unknown in the United States, although several patents for them have been obtained, and they are little used in any other country, so far as we are aware, except Tartary, Persia, and parts of Spain, where they are said to be occasionally employed. Their effective force is much less than the vertical mill, being estimated by Smeaton as only one tenth, but Sir David Brewster maintains the proportion to be one third or one fourth. They are formed of four upright vanes or sails, generally not helical, but at right-angles to an upright shaft, and the wind is allowed to enter one side of the inclosed building, and go out at the opposite side, while the remainder has movable screens to open towards any point of the compass. The slats in the vanes are sometimes arranged to open, or feather, in returning back towards the wind. We believe this form of mill might be greatly improved if attention were bestowed on it, and the same principles applied in directing the wind on the vanes, and the exit therefrom, as have been so successful in the mode of applying water to the turbine wheel.

The windmills of Holland are not only a notable and pleasant addition to the flat landscape, but they are of the greatest importance to the existence of the dikes and the sanitary condition of the land. From the high cost of fuel there, it is doubtful whether, without them, there would not be a most unfavorable revolution in all the business of the country. They are also efficient in a vast amount of work in all kinds of manufactures, so that they have become a national institution as certainly as the dikes which brave the waves of the ocean. In many districts the wealth of the burghers and farmers is estimated by the number of their mills, as we would count houses, farms, or stocks, and they form the most acceptable kind of inheritance to children.

The small mill, with a tail to turn it towards the wind, costs about $150, but the larger kind, similar to those we shall describe, often cost as much as $15,000, which, at our higher rates of labor, would equal $25,000 in the United States. Besides drainage, saw-mills, and grinding grain, the windmills are used for a multiplicity of purposes, such as oil, paint, snuff, mustard, drug, cement, and flax mills; and they especially are found in the suburbs of towns and villages in large numbers. The town of Zaandam alone has about 400, and 50 or 60 of them can be seen at once. Each large mill represents a capital of $50,000 to $60,000 in our money. The effect of so many immense arms turning on the flat landscape, especially at first view, is very singular, and some of the large drainage windmills placed on the embankments of canals form a most imposing feature.

The general appearance of the larger grain windmills of Holland is as follows: The basement is of stone or brick, supporting a tall superstructure of wood, capped with the revolving hood, which carries the main shaft and sails. The outside is handsomely thatched with straw, which is carefully attended to and often renewed. Occasionally, as in some at Amsterdam, the whole tower, about 60 feet in height, is of brick, flanked by low buildings on each side. On the ground floor are stables, wagon-houses, and store-rooms for feed, etc. In the first story, the granary and meal rooms, into which the seven or eight kinds of flour and feed come from above through spouts. The second floor is for bolting and separating. The third is the grinding-room, where there are usually three pairs of 5-foot stones. In a strong wind all these can be run, but almost the lightest breeze is sufficient for one pair. The Dutch mode of using a regulator, which sets the stones closer together, to make greater friction when the speed is too great, is not to be commended, for it tends to make irregular sorts, and causes unnecessary wear of the stones. It could be accomplished by much simpler means. There is a hoisting apparatus, by which all the grain to be ground is elevated through traps to the fourth story, whence it descends to the stones. This room contains the cleaning-machines, and just above is the ponderous main-shaft, which, with a slow grunting movement, through cog-wheels, pinions, and bevel-wheels, turns all the heavy machiney throughout the mill. A gallery, often 40 or 50 feet from the ground, surrounds the top of the tower below the cap. The Dutch use the ordinary windlass and ropes placed on the gallery for shifting the hood, to make the sails face the wind.

Most of the arrangements of these large mills are exceedingly ingenious and practical, showing that the mechanical skill possessed by the Dutch is greater than that with which they are usually credited. In fact, so indispensable has the windmill become in Holland, and so likely to continue important, from the scarcity of fuel there, that necessity and experience have taught many improvements and practical advantages. In the large drainage windmills, some fine examples of which can be seen at Rotterdam, the arms and sails—which may be as large as those just described—turn, by cog-gearing, only one large drain-wheel, having outside open buckets, which, working in a sluice against a short curve of masonry, lift or scoop the water up an inclined

plane to a level four or five feet higher. Another mill, situated farther on, will lift the same water an equal height to another level, and so on for, it may be, three additional lifts. This description of wheel will raise from 5000 to 10,000 gallons of water per minute, and is the kind always used in Holland, except where the Archimedian screw is substituted for the bucket-wheel. There are rooms in these mills occupied by families, and some of them are very quaint and curious, with their smooth, red-tiled floors, dark oak roofs, small, curtained windows, blue and white tiled chimney-pieces, and antique carved cupboards and chairs. There is generally a profusion of polished ornaments, and culinary utensils of brass, and many curious specimens of china and earthenware.—*American Exchange and Review.*

time past attached great importance—I refer to the getting rid for the most part of great curvature. Of course armor plates, if carried round the ends of a ship, must be bent to the curvature of the water lines, and when embedded, so to speak, in the sides of a ship of ordinary form and curvature—as has been usual in sea-going ships—they must also be bent crosswise. Now this double curvature of the plates is not only an expensive process, but it is also injurious to the armor plates in some degree. To foreign Governments which do not make their own armor plates, and especially to the Governments of countries very remote from England, the system will further be attended by extreme difficulty in replacing plates injured in battle. This could hardly be accomplished by the slow and expensive process of sending accurate moulds to England

vious cases in which this has been done, or even proposed, for main deck batteries, but it probably was at least proposed before, and I have a vague recollection or impression that Captain Symonds or Captain Scott once suggested it. My present object is, however, simply to say that in adopting the system I consider that the Austrian Admiralty have acted wisely, for it has many very great advantages, and no disadvantages of any moment that I have been able to discover even in a seaway. If Mr. Barnaby and his colleagues will excuse me for saying so, I think the Alexandra might have been improved by these means, for in her the fore-and-aft fire has only been secured by an enormous depth of recession of the sides beyond the battery, and a corresponding contraction of the upper deck, and other accommo-

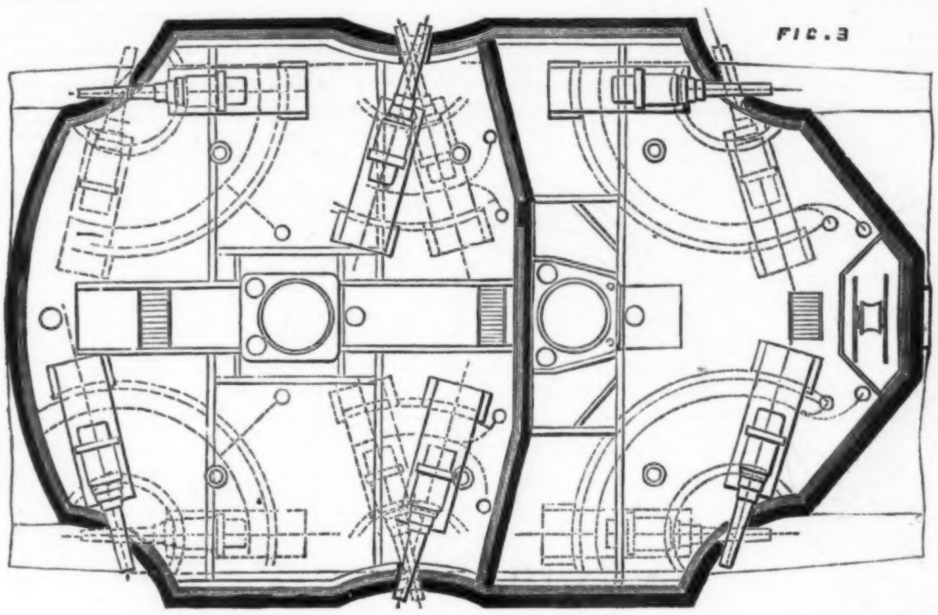


FIG. 3

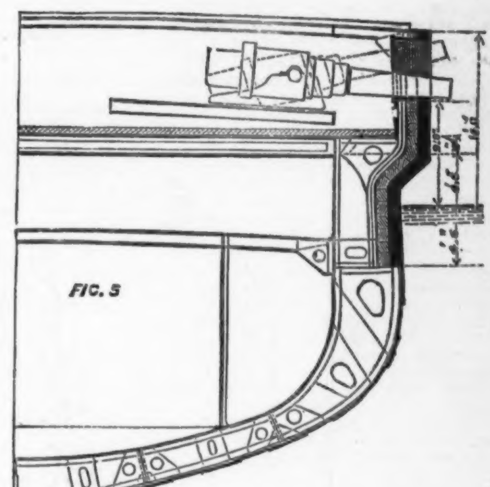


FIG. 5

AUSTRIAN IRON-CLAD WAR-SHIPS.

ON CERTAIN AUSTRIAN IRONCLADS.*

By E. J. REED, C.B., M.P., Vice-President.

THE first ship which I propose to mention, and very briefly to describe, is the new ironclad Tegetthoff, now under construction at the works of the Stabilimento Technico, at Trieste. This large and admirable establishment took the contract for the hull, engines and boilers in August last. I will first give the general dimensions and particulars of the ship, and afterwards make a few observations upon the more marked features of the design. The following figures give her dimensions, calculated elements, etc. Length between the perpendiculars, 286 ft. 11¼ in.; length, total, 303 ft. 1¼ in.; breadth on the water-line, 62 ft. 9 in.; extreme breadth to the outside of armor, 71 ft. 1¼ in.; depth of hold, 34 ft. 9 in.; draught of water, aft, 26 ft. 7¼ in.; draught of water, forward, 23 ft. 1 in.; displacement with the half of provisions, 7390 tons; area of the midship section, 1301 square feet; area of the load water line, 14,308 square feet; height of metacentre above centre of gravity of displacement, 14.623 ft.; height of metacentre above water, 4.770 ft.; distance of the centre of gravity of displacement before the midship section, 3.356 ft.; depth of the centre of gravity of displacement below water, 9.853 feet; co-efficient of displacement, 0.582 ft.; co-efficient of water line, 0.782 ft.; co-efficient of midship section, 0.82 ft.; displacement of an inch immersion at the load water line, 34.47 tons; weight of armor and backing, 2160 tons; the armament consists of six 11 in. Krupp guns. Area of sails, 12,165 square feet; cost of hull, estimated, £172,790; cost of engines and boilers, estimated, £81,715; nominal horse-power, 1200; number of cylinders, 2; diameter of cylinder effective, 125 in.; length of stroke, 4 ft. 3 in.; Griffiths propeller, diameter 23 ft. 6 in.; pitch, 24 ft.; number of blades, 2; revolutions per minute, 70; number of boilers, 4; area of fire-grate, 850 square feet; heating surface, 25,500 square feet; superheating surface, 1800 square feet; pressure of steam, 30 lbs.; number of furnaces, 36; mean indicated horse-power 8000; speed, estimated, 14 knots.

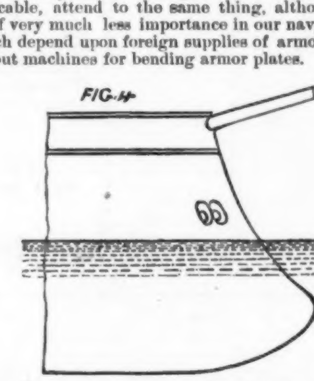
From these figures it will be seen that although we are not dealing with a ship of the Inflexible (English) or of the Dandolo (Italian) type, in which armor of excessive thickness is placed over a central citadel of extremely limited extent, we, nevertheless, have a very powerful ship indeed, with armor of apparently about 13 in. to 14 in. thick, and with a concentrated battery of six 11 in. Krupp guns, each weighing, I presume, about 27 tons. The ship has a belt of armor extending from the stern to within about 30 ft. of the foremost perpendicular, where it terminates in a transverse armored bulkhead, and a stout iron deck going forward to the stem at about 7 ft. below water. It would appear from this that the Austrian authorities consider that a strong iron stem, supported by a stout deck near the point of the ram, is sufficient for ramming purposes, whereas in our navy we have thought it better—beginning, if I remember rightly, with the Rupert and Hotspur—to keep the bow armor, and carry it down at the stem to considerably below the ram point. We may take it for granted, I think, that the latter, or English arrangement, would at least have the advantage of protecting the ram bow from much local damage in ramming iron vessels, and this is no doubt very desirable where a ship is designed primarily as a ram—as were the Rupert and Hotspur—while, on the other hand, where the ram is a subordinate feature—as in the Tegetthoff—it may be unnecessary to burden the bow with so much armor protection. It is worth while to observe in this connection that the Austrians, who have had practical experience of the effects of ramming in actual warfare, have in this, their largest and most powerful ship, preserved a very great length of under-running or spear projection, as shown in the diagram Fig. 4. The projection is 9 ft. from the stem at the load water-line, and 19 ft. from the stem head.

I observe next, in this ship the Austrian Admiralty have adopted an improvement in armor to which I have for a long

* Institution of Naval Architects.

for the guidance of the manufacturers. By so designing the ships that the armor plates have only to be curved in one direction, all these disadvantages and difficulties are practically got rid of, and therefore, in recent ships which I have had occasion to design for foreign Powers, I have carried out this principle, and Herr Romako, in a letter to me, says:—"With your encouragement I have undertaken to give the stern a form which enables the bending of the plates to be performed in only one way." I believe I am right in saying that Mr. Barnaby and his colleagues at the Admiralty, as far as practicable, attend to the same thing, although it is, of course, of very much less importance in our navy than in navies which depend upon foreign supplies of armor and which are without machines for bending armor plates.

FIG. 4



The next feature to be remarked in this ship is that the battery is of the projecting type, which so greatly facilitates the obtainment of direct fire ahead and astern from a midship battery without excessive recession of the unarmored parts of the ship before and abaft the battery. The Admiralty constructors and myself introduced this arrangement in many cases of upper deck batteries in ships designed while I was at the Admiralty (most notably in the case of the Audacious class), but I do not think the same thing has been done at the Admiralty in the case of the main deck battery. I have, however, done it myself in several ships for foreign Governments, since I left the Admiralty, and I give examples in Figs. 1 and

FIG. 2

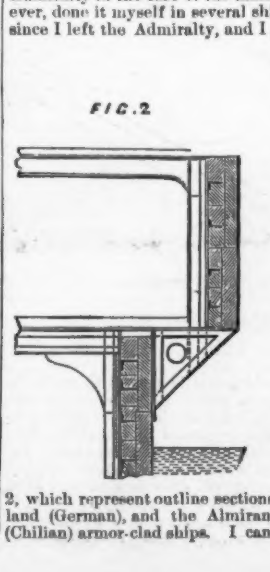
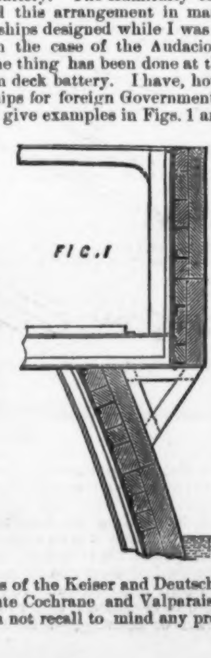


FIG. 1



2, which represent outline sections of the Keiser and Deutschland (German), and the Almirante Cochrane and Valparaiso (Chilian) armor-clad ships. I can not recall to mind any pre-

dation. In the Tegetthoff the overhang is very low and considerable in amount, the battery projecting between 4 ft. and 5 ft., the spread commencing at 18 in. above the water, and terminating at a height of 6 ft.

A still more novel feature, one which, although I have seen it suggested before, has never before to my knowledge been carried out, is illustrated in Figs. 3 and 5. It consists in depressing the sides of the ship into curved indentations in wake of the guns, as there shown. The object mentioned to me by Herr Romako, as that which has been sought in the arrangement, is the protection of the gun-muzzles. In mentioning the general form of the battery, and more particularly this feature, he says:—"The ship Tegetthoff is in many regards a novelty, its casemate allowing an all-round fire, avoiding at the same time, by its particular form, the dangerous projection of the muzzle of the midship guns, in consequence of experiences acquired in the battle of Lissa, but which are very little known even in our own navy." It will easily be seen that in addition to the advantages assigned, this depression of the port likewise possesses the advantage (if designers chose to avail themselves of it) of affording increased horizontal training for the guns, by bringing the pivot in from the line of the ship's side, and as the armor comes in with the pivot, this end is attained without that enlargement of the port which would otherwise attend it.

The plan in Fig. 3 further shows that the Tegetthoff is also to be furnished with a transverse bulkhead abaft the foremost gun, an arrangement which will prevent the battery from being raked in chasing. This improvement exists in the Alexandra, where it was, I believe, introduced for the first time by the present Admiralty constructors. The foremost bulkhead of the battery is inclined forward at a considerable angle to within about 4 ft. of the middle line, where it becomes transverse, as shown. Immediately over this foremost portion of the battery at the middle is a very strong pilot-tower, standing well up above both the gunwale and the forecastle. This shows that the Austrian officers, who have been in an action with ironclads, do not consider such towers unnecessary.

The above appear to me to be the principal features of the Tegetthoff. It may be interesting to add that while the outer skin and angle irons of the hull are of iron, all the remainder is of Bessemer steel, varying in tensile strength from 30 to 33 tons per square inch of section, and possessing this, as I am informed, in combination with 25 per cent. of ductility. This Bessemer steel is produced very successfully in Styria and Carinthia, from which districts of Austria the chief supplies for the Tegetthoff are derived. I may further add, that in designing this ship much consideration has been given to securing both strength and subdivision, by means of water-tight bulkheads between the coal spaces and the boilers, and elsewhere.

I have not hesitated in describing this ship, as above, to mention its various novel features in relation to similar improvements in our own navy where these have taken place, because the whole design, with its many meritorious novelties and combinations, seems to me to reflect the utmost credit upon Admiral Pöckh, Herr Romako, and other Austrian officers who have been consulted, and who have taken part in the preparation of it. It may also be said in this connection that as the primary duty of a naval designer is to produce the best possible design for his employers, so his success and his merit result from the accomplishment of this great object, rather than from scheming improvements merely for the sake of displaying originality. I trust this Institution will concur with me in thinking that our thanks are due to the Austrian Admiralty for enabling me to describe, at least in outline, their newest and most important ironclad ship. Perhaps I ought to say, with reference to the very low estimated cost of the Tegetthoff, that the sums which I have given do not, I believe, provide for anything more than the bare hull and engines.

In conclusion I may mention a very striking instance of conversion which has taken place in the Austrian navy, to which I made a slight reference recently in Parliament.

When last at Trieste, I was much interested in finding that certain wood-built ironclads of an early date—the Kaiser Max, the Prinz Eugen, and the Don Juan—were being taken to pieces, with the object of replacing the wooden hulls with hulls of iron, advantage being taken of the superior lightness of the iron hull by providing for a considerable increase of armor strength in vital places. The original engines and most of the fittings of the wood ships are being used in the iron ones, and I learn that this object is being carried out with great economy. Herr Romako says: "With the reconstruction of the three armorclads of the type Kaiser Max, the Austrian navy has maintained her rank as a Maritime Power, while for the same money we could hardly get but one ship like the Albrecht—about the same as the English Triumph class. It is true that the engines of the three old ships can not give a higher velocity to the new ships than 12 knots, but instead of only one ship we now possess three rams—the most dangerous and secure weapons, I consider, and compared with which the action and effect of the aggressive torpedo is, in my opinion, doubtful and insecure, and may easily endanger the ships of its own fleet."—*The Engineer.*

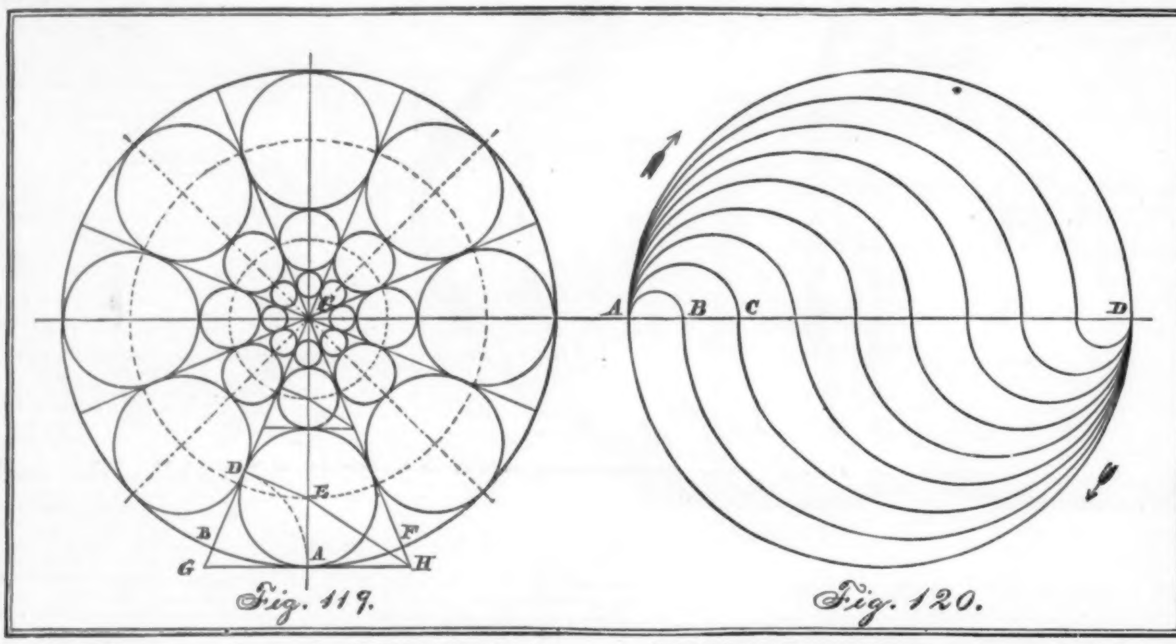


Fig. 119. *Fig. 120.*

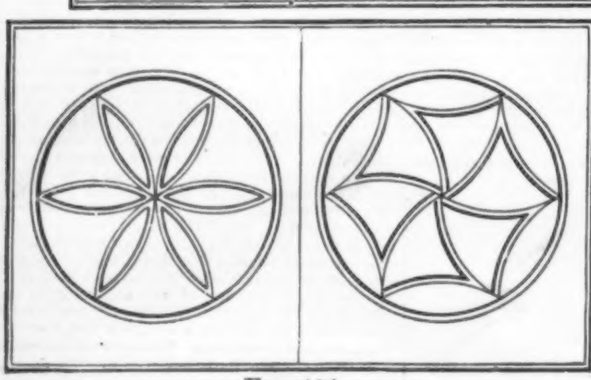


Fig. 121.

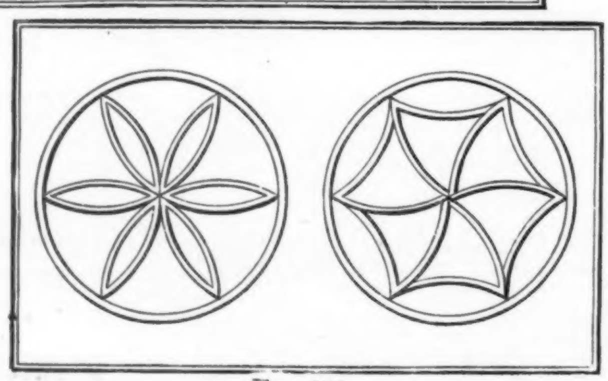


Fig. 122.

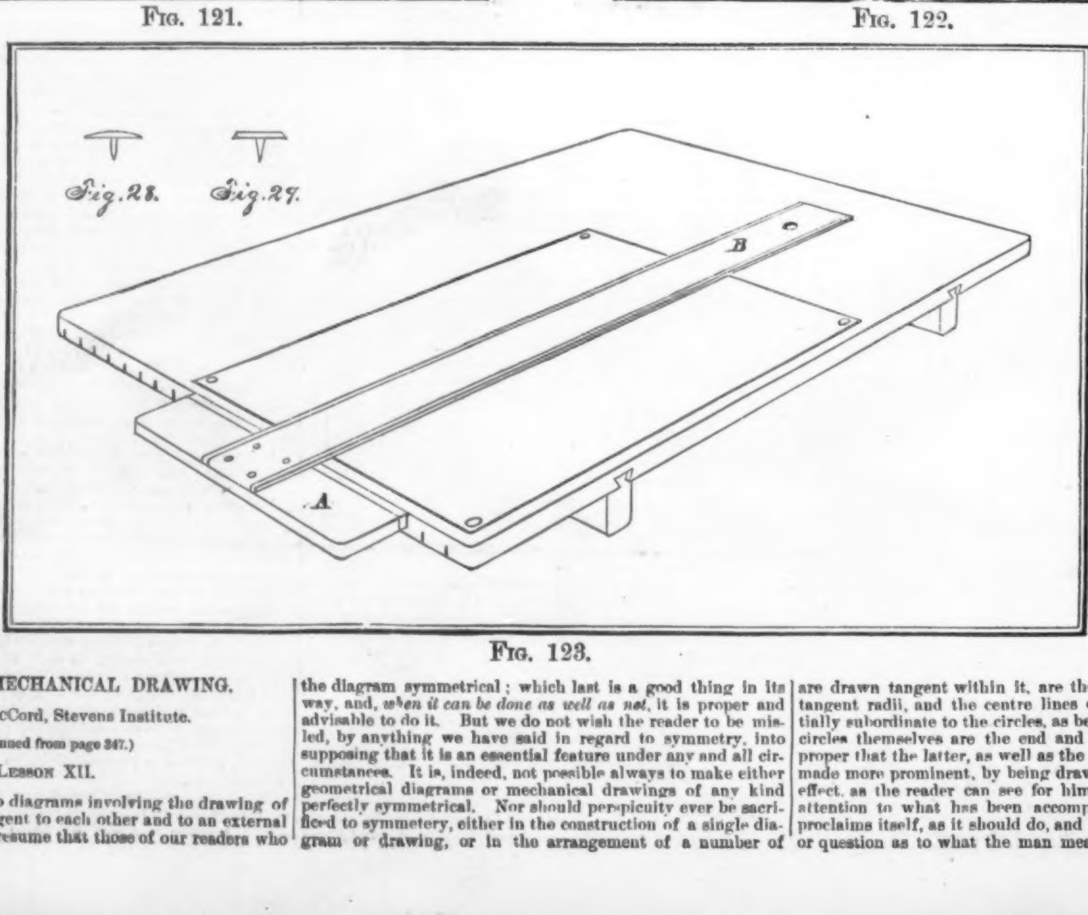


Fig. 123.

LESSONS IN MECHANICAL DRAWING.

By Prof. MacCord, Stevens Institute.

(Continued from page 347.)

Lesson XII.

We again present two diagrams involving the drawing of a number of circles tangent to each other and to an external one. By this time, we presume that those of our readers who have given the previous figures of this description a fair trial, are not disposed to class them among the most easily executed of exercises; and on that very account they may be classed among the best.

In Fig. 119 it is required to draw eight circles tangent to each other, and also to the given external circle. It is evident that each of these circles will be tangent to the radii, as C B, C F, which divide the given circle into eight equal parts, and that their centres will lie on the radii which bisect the angles included between the others, as, for instance, on C A, etc.

Draw at A a right line tangent to the given circle, cutting C B, produced, in G: on G C set off G D equal to G A, and at D erect a perpendicular to G C, cutting C A in E, which will be the centre of one of the outer row of circles.

Otherwise, let the tangent cut C F produced in H: bisect the angle C H A, and the bisecting line will also cut C A in the point E. Thus we have a check upon the accuracy of either construction; and besides, if the student chooses to draw this figure, as we have drawn it, in such a style as to illustrate and keep a record of the steps of the construction, the arrangement shown is a good one, as it not only does this, but makes the diagram symmetrical; which last is a good thing in its way, and, *when it can be done as well as not*, it is proper and advisable to do it. But we do not wish the reader to be misled, by anything we have said in regard to symmetry, into supposing that it is an essential feature under any and all circumstances. It is, indeed, not possible always to make either geometrical diagrams or mechanical drawings of any kind perfectly symmetrical. Nor should perspicuity ever be sacrificed to symmetery, either in the construction of a single diagram or drawing, or in the arrangement of a number of figures on a sheet—a point in regard to which we shall have more to say hereafter. Having completed the outer row of circles, it is clear that we could, if we chose, draw a new circle within them, concentric with the outer one, and like it tangent to them all. This, however, we have not done; but if we had, obviously the line tangent to the top of the lower circle, whose centre is E, would have been tangent to the imaginary one, and a repetition of the process above described would result in the production of a second row, as shown, tangent to each other and to the ones first drawn. And so we may go on, as far as the scale of the drawing and the capacity of our instruments will carry us. We recommend the drawing of these exercises two or three times as large as the engravings; and in order to produce the best effect, attention should be given to one or two principles, which, when judiciously observed, do a great deal towards relieving the monotony and tameness which too commonly render a mere diagram the reverse of attractive: and this figure gives a good illustration. It usually, though not always, happens that in such a diagram some of the lines are of more importance than others; for instance, in the case in hand, the given circle, and those which are drawn tangent within it, are the leading features. The tangent radii, and the centre lines of the circles, are essentially subordinate to the circles, as being the means, while the circles themselves are the end and object. It is therefore proper that the latter, as well as the original circle, should be made more prominent, by being drawn in heavier lines. The effect, as the reader can see for himself, is at once to attract attention to what has been accomplished; the final result proclaims itself, as it should do, and leaves no room for doubt or question as to what the man meant to do who made the

diagram. It is to be understood, of course, that these remarks apply only to *illustrative* diagrams—those of which the purpose is to explain a process. If this figure were intended to serve as a foundation for other work—if measurements were to be taken from it and used in the construction of other diagrams—it would obviously be improper to impair its accuracy, which this thickening of certain lines unquestionably does. But such illustration is very frequently the sole purpose for which a geometrical diagram is intended; and when it is, it may safely be said that, as a general thing, it will not only look more lively and attractive, but will serve its purpose better, if centre-lines and construction-lines be kept subdued, and the given and required lines be made bold and prominent. We do not say that this or any cast-iron rule, rigid and inflexible, will always apply; there is much room for the exercise of good taste and good judgment, of which experience is the best foundation. Sometimes it will happen that certain of the centre-lines or the construction-lines are very self-important, and insist on forcing themselves on the beholder's notice, and we can not get along comfortably without humoring them. Others, again, are more modest, and are contented to be distinguished by comparative obscurity—as by being dotted, or drawn faintly. But in one way or another, it is within the draught-man's power to make a plain diagram far more agreeable to the eye, and at the same time more readily understood, than it too often is.

In Fig. 120 is given an exercise combining simplicity with difficulty in a remarkable degree. The construction almost explains itself. The diameter of the given circle is divided into any number of equal parts, and each segment, as A B, B D, A C, C D, etc., is made the diameter of a semicircle, in the manner shown. Thus all the semicircles on one side the diameter A D are tangent to each other and to the given external one at A; all those on the opposite side at D, and the points of division B, C, etc., are points of tangency between semicircles on opposite sides of A D. In this case there are no construction-lines, and the circles are drawn in fine lines, as they not only require no distinction from other lines, but an attempt to make them heavy would result in a certainty that they would run together and form simply a black mass at both A and D.

This exercise will be found to require the most careful handling of the instruments. If it be attempted in the order above set forth, it will be found better to draw a line just below the diameter, in pencil, to subdivide that with the dividers or by the method of parallels (Fig. 33), and then to draw very short perpendiculars through those points of subdivision, in order to transfer them to the actual diameter; for otherwise we may prick minute holes on that line, just enough out of place to make it difficult to shift the needle-points of the compasses to the correct spot without having them slip back. A compromise may be made, by assuming the half of one of the segments, as A B for instance, and stepping it off the desired number of times, thus marking the centres, and then drawing the circles—which last of itself is a task of considerable delicacy, and the student is advised to try this mode of operation first.

Very slight inaccuracies in the execution of this diagram are likely to make themselves more conspicuous than in any that have preceded, for this reason. The semicircles tangent at A, for instance, form with each other what may be called curvilinear angles; these are not equal, but decrease as we go outward, and the rate of diminution is not uniform, but itself decreasing. By reason of all this, the most insignificant error in a centre or a radius will have the effect of changing the correct relative sizes of two adjacent angles; and the consequent lack of regularity in the gradation will be detected with surprising celerity by the practised eye.

In drawing the lines with ink, the semicircles which are tangent at A should be drawn *from* A, as shown by the upper arrow, beginning with the largest, the ink allowed to dry perfectly before beginning the next, and so on in order; then turn the board or paper round, and proceed in like manner from D, as shown by the lower arrow, in drawing the other series.

We have surrounded these two figures by a border, which may be considered as enclosed within a rectangle, representing the edge of the sheet, upon which the exercises are drawn. Although in working plans it is rather out of place to make any such pretensions to ornament, it is not so in making a series of practice exercises, and it is often required to make neatly finished drawings of machines, for purposes of illustration and exhibition, and it is well for the student to give some attention to the matter, that he may not be at a loss in case he is called on to produce something of that kind. The simplest and in many cases the best border consists merely of a double line, as has been explained in Lesson V. In arranging the different figures which are to be drawn upon one sheet, with reference to a border of this or any other description, attention must be given to the spaces between the separate members, and also to those between them and the line of the border itself. And we wish particularly to point out one circumstance in connection with these two figures: which is, that the space between them is *not* twice as great as the space between either of them and the border line at the end. A very common proceeding, when two perfectly symmetrical figures, as in the present instance, are to be placed side by side, is to draw a fine line vertically through the centre of the sheet, as shown in Fig. 121 (the border having been laid out first). Then each figure is drawn exactly in the centre of the compartment thus provided for it, and the dividing line then erased. This is so often done, and the effect produced by it is so bad, that we have thought it worth while to illustrate it and its cause. Were this dividing line inked in, the effect would be good, as Fig. 121 shows; but as soon as it is rubbed out, as in Fig. 122, the two figures appear too far apart, and as though they repelled each other: the eye becomes conscious at once of something wrong, and looks uneasily around for the reason why this was done. The fact is, that each figure, as one may say, is a border to the other, on the adjacent sides: and as shown by Figs. 119 and 120, there is no need of leaving a space between them much if any greater than is allowed between their outer ends and the border line.

Before going farther, it is proper to halt long enough to describe an instrument which is all but essential to the draughtsman who wishes to get through his work with dispatch. We mean the **T** square, doubtless familiar to many of our readers, who may have wondered at not meeting with allusion to it long ago, as it is usually considered to be absolutely indispensable.

This, however, is not the case, even in ordinary mechanical working drawings of machinery: although it is not to be denied that it so greatly facilitates their execution that it would be absurd to attempt to get along without using it. What we mean to say is, that it *can* be dispensed with; and what has been aptly called "a fluent use of the triangles" is so important, that we have purposely confined ourselves to them.

The **T** square, with its inseparable companion the drawing-board, is shown in Fig. 123. It consists essentially of a blade or ruler, B, fixed at right angles to a stock or head, A, the whole resembling the letter T in form, whence its name. The drawing-board is merely a smooth rectangular board on which the paper may be fastened with pins, as shown. It will be seen at a glance that by sliding the stock of the square along the end of the board, we are enabled to draw a series of parallel lines, lengthwise of the paper; and if the stock be applied to the *side* of the board, and moved along it in like manner, we shall have another series of lines, parallel to each other, and at right angles to the first series. That is, *provided that the side and the end of the board are at right angles to each other.* If they are not, it will be seen that the two series of lines will make with each other the same angle that the side and end of the board make. Which leads us to speak first more particularly of the drawing-board: and assuming that there may be among our readers those who are able and desirous to make or have made the best, we describe and illustrate that which has proved itself to be such, though we wish it to be understood that it is not *necessary* that this expense or trouble should be incurred. Any smooth piece of pine will answer a purpose; but when much drawing is to be done, it will be found good economy to procure the best appliances. Many different forms of boards have been proposed and made, but for the ordinary purposes of the draughtsman whose work is in the line of machinery, the following instructions will furnish one which will give perfect satisfaction, as has been proved by years of experience.

As shown in the figure, the board is made of a single piece, without framing or panelling; if of large size, the requisite breadth is to be made up by simply matching the separate pieces, and gluing the edges, without tongues or grooves. In order to prevent the board from warping, two battens of hard wood are fitted into dovetailed grooves at the back; they should be accurately fitted, so as to require to be driven in, but not on any account glued, screwed, or otherwise fastened; the object is to permit the board to expand or contract as it will, sliding slightly on the battens, the stiffness of which is relied on to prevent the warping. And in order to diminish the tendency to warp, and to weaken the board transversely, the latter is run lengthwise over a circular saw, making a series of slits half through its thickness, as seen at the end nearest the spectator in the figure.

For material, nothing is better than good clear pine wood, free from turpentine; it should be thoroughly seasoned and dried, but no amount of either will render it safe to fasten the battens to it, by screws or otherwise, as is sometimes done. The dimensions of a board must of course depend on the work to be done, and the fancy of the user; the one represented in the cut is of very convenient size for use, as a portable article to be placed on any table, being 33 inches in length, 20 in breadth, and ⅞ of an inch thick, the battens being made of ash, an inch thick and an inch and a half deep, placed about six inches from the ends; they are an inch shorter than the breadth of the board, so that under no circumstances may they project beyond the edge, which would interfere with the use of the square.

The paper is to be placed on the board in the position shown, the edge being a half inch or less from that of the board. It is to be observed, that the paper is placed nearest the lower left-hand corner of the board; this is the working or controlling corner, as the square is always used by simply grasping its stock with the left hand, and pressing it against the left end, or the lower side of the board, for drawing longitudinal and transverse lines. It is, therefore, essential that these two sides should be perfectly smooth and straight, that the square may slide freely along them, without rocking. And they ought to be exactly perpendicular to each other, for the reason that we wish these two series of lines to represent the horizontals and verticals in our drawings.

There is, of course, no objection to having the board made so perfectly that either corner might be used as the working corner, and it is, in fact, occasionally convenient to draw lines, especially in very large plans, by applying the square to the top, or to the right-hand end. But such a degree of accuracy is not easily attained, nor is it at all necessary that it should be.

The side and end may be tested in the manner explained for trying any ruler or straight-edge, in order to determine whether they are perfectly true; then, to ascertain whether they are at right angles, it is necessary to have a good **T** square, with which a line is drawn parallel to the end, and another to the side, intersecting anywhere near the middle of the board. These lines ought to be perpendicular to each other; in order to test this relation, describe a circle about the intersection as a centre, and see whether the four parts into which it is divided are equal, as they should be. Finally, it is to be remarked that although the angle included between the side and end must be a right angle, the corners of the board need not be sharp, but on the contrary it is well to round them off with a small radius, say three-eighths of an inch, as they are then less liable to be injured by accidental blows.

For larger work, boards of corresponding size must be used, and are frequently made to be set on a permanent frame, being in fact, as in name, drawing *tables*, which we may describe more fully at a future time. But no matter what the dimensions, they may be constructed to the best advantage on substantially the same principles.

The material may be to some extent a matter of taste, but there is none better in all essential respects than good clear white pine, straight-grained, and free from knots; while boards with fixed battens, boards with framed or panelled edges, and boards with movable centres or backs, are to be avoided as radically faulty and needlessly expensive.

Now as to the **T** square. This is made in a great variety of forms and materials, and with infinite variations in proportions and dimensions. For ordinary use we prefer wood, which should be fine grained and hard: if of a single piece, perhaps satin-wood is as good as any for the blade. It has the disadvantage of being nearly white—and we have represented in the cut a blade of mahogany, with ebony edges, an article lately introduced into the market, and by far the best thing of its kind which we have met with; the superiority of ebony for the marking edges of wooden rulers is decided and unquestionable, on account both of its fine grain and its dark color. The stock is of less importance, and may be of rosewood or mahogany, preferably the former, unless, as shown in the cut, it be also faced with ebony, which wears better in sliding along the board.

But whatever the materials, let it be observed that the blade is not let into the stock, but merely fastened to the upper side of it, usually by gluing, as well as by the four screws shown. This is a very important feature, and for what reason will be clear by looking at the figure, where it is seen that the upper side of the stock does not project above the face of the board, but is *flush*, or on the same level, with it. Thus the triangles, when used, as they continually are, in connection with the square, are free to slide over the stock, and this enables us to draw lines with them up to the very edge of the paper. "But," may say the dealer who has not this kind in stock, "don't you see, my dear sir, that you can only use the upper edge of your blade? Now here is one made as it should be, with the blade let into the stock, so that you can turn it over and so use both edges." Just so: but these instructions do not go beyond the use of one edge at a time; and as for the other one, there does not appear to be a good reason for calling it into service, unless the instrument be used for practising the broadsword exercise, as the manner of some is. "But," he proceeds, "how can you tell whether the blade and the stock are at right angles,—whether in fact your instrument is a **T** *square?*" Well, it would be a little troublesome to ascertain this, though if it were worth knowing it could be done. But it is not worth knowing; Mr. Dealer shows how simply it is to be tested with the other form,—you have only to draw a line, turn the square over, and draw another line by the same edge, and "see there, they coincide exactly." And the unreflecting novice is very apt to think that if the blade and stock of his **T** square are not exactly perpendicular to each other, it is to be set down against him as a sin of omission, and he must put on mourning and look unhappy till the matter is rectified. But, since the directions of the lines are governed by those of the sides of the board, it needs only a moment's thought to show that the angle between the stock and blade is of no consequence whatever; it looks a little better, to be sure, if they be at right angles, and that is all. Were it otherwise, the squares with swivelling heads, for the purpose of drawing lines inclined to the vertical and horizontal ones, would require some additions. Of these we do not here speak, as they are comparatively seldom used,—we shall show by and by that they too can be made so as to secure the same advantages as the one in the cut, although almost universally made so as not to do it.

As to the dimensions of the square, they must largely depend on those of the drawings to be made: for use with such a board as we have shown, the blade may measure 30 or 32 inches in length, in which case it should be about 2¼ inches wide, and $\frac{3}{16}$ of an inch thick, the stock 10 inches long, 2¼ wide, and $\frac{7}{16}$ thick. Larger squares necessarily have the blades of greater thickness; and it then is advisable to chamfer the edges, since a ruler whose marking edge is much more than a sixteenth of an inch thick is very inconvenient in use, obstructing the vision, and, worse than that, making it difficult to steady the pen or pencil properly, because this must rest against the upper corner of the ruler, and thus the point of support is too far from the end for security.

Squares are made, as we have remarked, not only of a great many different kinds of wood, but of other materials—such as metal, and hard rubber: the latter is too flexible and too treacherous. For extremely accurate work, it can hardly be disputed that a steel blade, nickel-plated, with a metallic head, is superior to any thing else—of this we shall speak hereafter, in connection with appliances for giving a metallic edge to the board as well. But for by far the greater part of the work of the mechanical draughtsman, a simple wooden square, as described, will be found all that is wanted. In regard to its finish, the best polish that the wood itself will take, without varnish of any kind, will answer a good purpose; but if the reader be disposed to purchase the very best, it may be stated that those like the one illustrated are also to be had, in which the pores are filled with a varnish or polish of some kind, which not only gives the wood a beautiful gloss and adds much to its appearance, but is a positive advantage in respect to the facility of keeping it free from dust.

As to the board, that should not be painted, varnished, oiled, or in fact have any thing done to it whatever, beyond smoothing its face only with sand-paper. If it be oiled, it will collect dust, and spoil the paper: if it be varnished or painted, it will not be possible to paste a sheet down if we want to, while no good can possibly result from either proceeding.

We have shown the paper secured in place, as before recommended, by means of four pins or thumb-tacks, which were described in Lesson VI.; but the illustrations of their forms, good and bad (Figs. 28 and 29), were accidentally omitted. We supply this omission here, and it is perhaps as well that these are thus shown side by side with the board and square, as the reader can thus more readily see why it is that the form of Fig. 28 is better than that of Fig. 29, as previously explained.

And it will be also apparent, that if this mode of securing the paper in place is to be adopted, the board ought to be of soft wood: for if it be hard, the pins are not only difficult to remove, when necessary, but, if as small as they ought to be, they are liable to be broken off in the attempt; which is exceedingly annoying, not only because another pin may strike the broken one at another time, but when it is required to face off the board again, which will happen sooner or later, these bits of steel will spoil the edge of the tool and the temper of the workman.

Aside from this, there is no special objection to the use of harder woods, if the fancy of the draughtsman is pleased with them; but they are unnecessarily heavy, and they are more costly, without being in the smallest particular better adapted to their purpose; and as combining all essential requisites, in the most perfect manner and with the least expense, we have no hesitation in recommending the implements shown in Fig. 123.

HOW BLOSSOM ROCK WAS REMOVED.

PRIOR to the year 1870, there existed a dangerous obstruction to the safe navigation of the harbor of San Francisco, in the form of a ledge, known as Blossom Rock.

The following drawings and account of the rock and its removal are from the excellent report of Col. R. S. Williamson and Lieut. W. H. Heuer, U.S.A., who were the supervising engineers under whom the whole work was executed. The success of the work on Blossom Rock led to the adoption of the same method for the removal of the Hell-Gate and Flood Rocks, New-York City. The Hell-Gate rocks, at an expense of several millions, have been undermined, and are to be blown up this summer.

Blossom Rock was situated in San Francisco Bay, directly east of the Golden Gate, or entrance to the bay, due north of the city, on a line between Alcatraz and Yerba Buena Islands, and nearly midway between them. It was distant from the city front about 1500 yards. It was directly in the course vessels are often compelled to take in entering and leaving the harbor; was in the track of naval vessels passing to and from San Francisco and Mare Island navy-yard, and was also in the way of all passenger steamers and vessels plying between San Francisco and the Sacramento and San Joaquin Rivers. The rock was discovered and named in 1826 by Captain Beechey, Royal Navy, F.R.S., who entered San Francisco harbor in command of His Britannic Majesty's ship The Blossom.

The top of the rock was about 5 feet below the surface of

the water at mean low tide. Its greatest length at the depth of 24 feet was 195 feet, and its greatest breadth at the same depth was 105 feet. The quantity of rock to be removed to obtain a depth of 24 feet of water was 5000 cubic yards. A portion of the top of the rock, about 34 by 22 feet in size, was comparatively level, but two of its opposite sides sloped off quite rapidly into deep water. The place is exposed to south-east gales which prevail here in the winter months, and the tide whirls over the rock at such a rapid rate that the buoy, which the Light-House Department placed there, has several times been swept away.

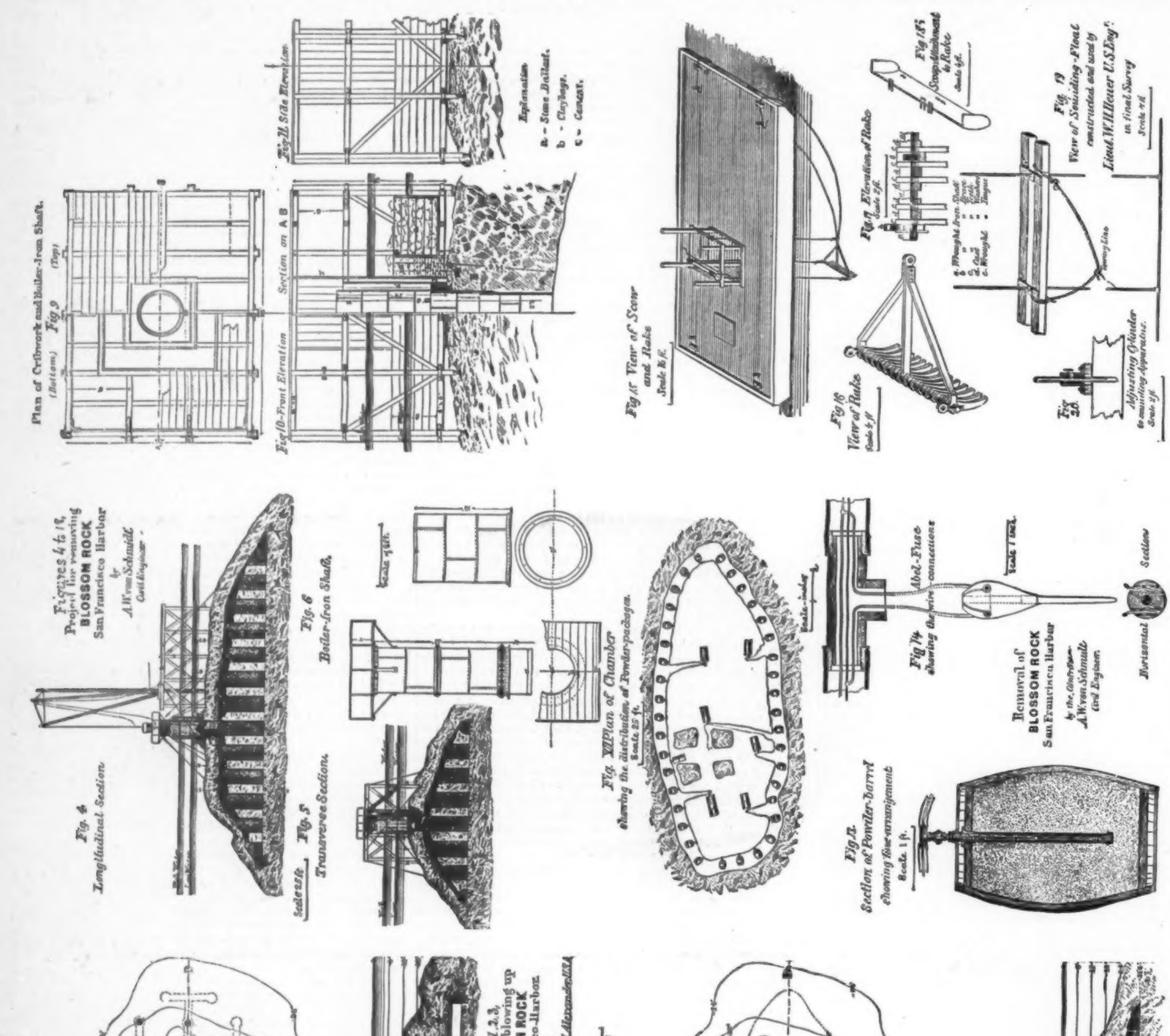
The rock was a metamorphic sandstone of a variable de-

plosives. In a letter to Col. Wilkinson on the subject he observes:

"The removal of so large a rock by surface blasting will, I fear, be a long, as well as an expensive undertaking. After a good deal of reflection on the subject, I have arrived at the conclusion that it may be done in a single season, and at greatly reduced cost, by undermining the rock, making a number of powder chambers under it, and blowing the whole rock to pieces at a single operation.

"To do this, I propose to enclose a small surface of the rock by a water-tight coffer-dam; in this space to sink a rectangular shaft about 4 feet by 9 feet, which is the size I have seen

It will not be necessary to try to get a smooth surface. All that is necessary is to get a surface upon which the coffer-dam will stand. (See Figs. 1, 2, and 3.) This being done, I propose to frame a strong coffer-dam of 12-inch square timber. This may be built on shore, and made water-tight. It should be built up so as to be 13 feet high before launching. It will then, if built of Oregon pine, draw about 10 feet of water, and may be easily towed out and anchored over the spot where it is to be placed. It will then just ground on the rock at low water, and by the aid of ballast, say bags of sand placed upon platforms, or otherwise fastened to the dam, be prevented from floating as the tide rises. The next operation



REMOVAL OF BLOSSOM ROCK, SAN FRANCISCO HARBOR.

gree of hardness, of a brownish-yellow color, of irregular stratification, and in some places contained small beds of gravel cemented together with a bluish substance resembling clay. The specific gravity of the great mass of the rock was 2.64, a cubic foot of it weighing 165 pounds, and was so soft as not to require blasting; but in some cases it had a bluish tinge, and was as hard as granite.

Soundings having been made, the exact form of the rock was determined, and the quantity of rock necessary for removal to give a depth of 24 feet at low water was ascertained. Estimates were made of the cost of removal by the plan of surface blasting, and the calculated cost was $300,000.

In October, 1868, Brevet Brig.-Gen. B. S. Alexander, U.S.A., suggested the removal of the rock by sinking a coffer dam upon the rock, then tunnelling and blowing it up with ex-

in coal mines; from the bottom of this shaft to run tunnels and make powder chambers in such positions that, when exploded, the whole rock, down to the level of 24 feet below the level of low water, will be lifted in the air and shivered to pieces.

"I propose, in the first place, to blast off a small portion of the top of the rock, or what we call surface blasting, down to about the reference of—10', or 10 feet below low water. This is for the purpose of furnishing a comparatively level surface upon which to build a coffer-dam. This blasting operation will consist in lowering down charges of from 100 to 300 pounds of gunpowder to the surface of the rock, over the part to be removed, in water-tight vessels, and exploding them by means of Beardslee's magneto-electric machine, and afterwards removing the shattered portions of the rock by men in armor.

will be to fill up the inside of the dam so as to make it water-tight. I have supposed that we will use concrete placed in bags to fill it up to the low-water level, though it is altogether likely some cheaper material may be found to answer. If bags of concrete are used, they should be about half filled, and of such a size as not to weigh more than 50 or 75 pounds when immersed in the water. When ready to be put in place, a man in armor would go down into one of the compartments of the dam and place them in the crevices of the rock, taking care to fill up solidly the spaces under the timbers, particularly below the timbers which connect the inside with the outside walls of the dam, under which there would otherwise be leakage.

"The middle compartment of the dam is to be kept open, and it is supposed when the dam has been finished in the man-

ner described that this compartment will be practically water-tight. All that is necessary, therefore, to reach the surface of the rock within this space will be to pump the water out of it.

"If the dam is found now not to be entirely water-tight, it may easily be made so by caulking between the inside sheeting piles, and between their lower ends and the surface of the rock.

"We are now prepared to sink into the rock. I have supposed it to be 4 feet by 9 feet in the clear, leaving a ledge of 12 inches between its edges and the face of the sheeting piles on the inside.

"I suppose that this shaft will be sunk so that its bottom will be in the reference of—36′, and at this level small tunnels will be run under the rock, as shown in plan in Fig. 1, and in Figs. 2 and 3.

"In these tunnels, 55 separate chambers for powder will be placed, as shown in plan, and connected by insulated wires with the battery or machine for exploding them. Water will then be admitted through the sluice for tamping, and the whole space filled, pumping water into the middle compartment until it is filled to the top or reference of 10′. The mines may be fired simultaneously by the use of about three of Beardslee's machines.

"The quantity of powder that would be necessary to lift the rock and the water above the mines would be about 13,000 pounds; but as it will be desirable not only to lift the rock, but to break it up into small pieces, and blow it away as much as possible, I would recommend that about double this quantity of powder be used—say 26,000 pounds—the quantity of powder in each chamber being proportioned to the weight it will have to lift, or to the work it will have to do."

The estimated cost of executing the work was calculated by Gen. Alexander to be $41,000 in gold.

"I do not," he says, "make any estimate of the cost of removing the broken rock after it has been blown to pieces, because it is impossible beforehand to tell what operations will be necessary in order to accomplish this object. If the rock is any thing like that at Lime Point, and if it is shattered like the blasts there have shattered that rock, the currents in the course of a year would remove the greater portion of it. But if it should be a stronger rock and come out in larger masses, it would have to be removed by mechanical operations, and at considerable cost, which, however, would be far less by having the whole rock broken to pieces down to the required depth, than would be the case if the rock had to be blown up by piecemeal, involving a removal of the *débris* after each successive series of blasts.

In November, 1868, Mr. A. W. Von Schmidt, C.E., of San Francisco, submitted a plan and proposal for executing the work, which he thus describes in a letter to Col. Williamson, and which with due formalities was accepted by the War Department in June, 1869, and thereafter successfully executed.

"The first object in view," says Mr. Von Schmidt, "is a thorough removal of the rock, so that vessels drawing 24 feet of water will be able to pass over the same at low tide. To accomplish this the mere blasting and breaking up of the rock would not, in my estimation, accomplish the desired object, as the rock in broken masses would still form an obstruction to the navigation of the harbor. I have therefore matured a plan by which the entire rock itself shall be excavated in chambers, as shown by Figs. 4 to 18 inclusive.

"The rock taken out of the interior compartments will be removed through a shaft and discharged into deep water alongside the rock. When the whole inside of the rock shall have been removed, I propose, finally, to blast the crust over the chambers and drop the same to the bottom of the excavation.

"To accomplish this the following mechanical operations will be necessary: I make my lodgment on the highest part of the rock, which is nearly or quite level at this point, being 5 feet under the low-water line, and having a sufficient area for the works necessary to be constructed. I moor a scow, for working purposes, in the position required. I then place a boiler-iron case 9 feet in diameter and 13 feet high, with flanges on the lower end, on top of the rock. This flange has a canvas apron, 3 feet wide, running entirely around it, and lying on the rock. I then place a lot of sand-bags on top of the canvas apron and around the case. To secure the case I use $1\frac{1}{4}$-inch round iron rods, the ends of which are firmly secured into the rock by 'Lewis holes.' Turnbuckles are also placed on each rod, for the purpose of tightening them up from all sides. After this has been done, I pump out all the water there is in this case, and make an excavation into the rock, downwards, for the purpose of erecting the main case, which is of boiler-iron, 6 feet in diameter and 17 feet in height. This is set within the outside casing, and also firmly set into the rock, and secured with anchor-bolts, in the same manner as the first case. After this is done I fill all the cracks between the casing and the rock with Roman cement, excluding the water from the interior iron casing.

"When it is found that the leakage has been thoroughly stopped, and the platform erected as shown in the plan, I commence sinking a shaft down through and into the main body of the rock to the depth required, at which point I place a pump for removing such water as may be encountered in carrying on the work. From the bottom of the shaft I commence tunnelling the rock in all directions. As fast as the rock is worked, it is brought to the centre shaft through the different tunnels, and placed in a tub, when it is hoisted by steam and discharged alongside the rock into deep water by means of a swinging derrick.

"The rock that will remain between the excavation and the water will be about 6 feet in thickness, supported by pillars 4 feet square and 10 feet apart from centre to centre. It is proposed to remove most of these pillars when the rock shall have been tunnelled, and to set up in their place wooden supports as often as may be required to sustain the weight overhead.

"When the entire mass of rock shall have been excavated, the work will be in readiness to receive the several packages of powder, in such quantities as shall be thought necessary, the wires being laid to the several torpedoes, and connecting with a magnetic battery placed in a vessel near by. The chamber is to be filled with water, and the torpedoes fired by the battery simultaneously, when it is supposed that the entire shell of rock will be broken into small pieces and precipitated to the bottom, the timber supports floating out, and the work completed in all its details.

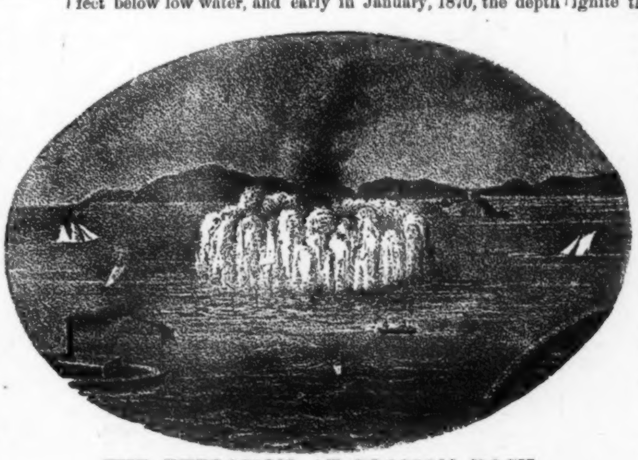
In October, 1869, Mr. Von Schmidt commenced operations. In order to place his boiler-iron cases in position, he desired to remove a portion of the top of the rock, to have a comparatively smooth surface on which they were to rest. He therefore constructed a scow 80 feet long by 30 feet wide, and having near its middle part a well about 10 feet square. Immediately over the well was constructed a framework of timber about 30 feet high, from which he could work the drills to be used in cutting off and smoothing the surface for the iron cases; but the scow was found to have so much motion that he was obliged to abandon the idea of getting the iron cylinders in position by that means. He therefore commenced the construction of a crib-work of timber, which was launched and floated over to the rock in November.

"The details of this crib are shown in Figs. 9, 10, 11. In its centre is a double tank or coffer-dam, about 10 feet square, built of plank, caulked and pitched; between the outer and inner portions of the coffer-dam was a space of 2 feet, which was filled with bags of tough clay. (*b*, Fig. 10.) The portion between the outer side of the dam and the outer edges of the crib was boarded up 6 feet high, forming a box around the dam. As soon as the crib was towed to its place, this box was filled with ballast (about 200 tons of loose rock), which caused the crib to rest on the rock. Anchors were then carried out from the crib, and the chains connecting them with its angles were drawn taut. Steel-pointed piles were next driven around its outer edges, and the rock being soft, they soon held it perfectly firm. On its top a floor was now laid, at a height of 20 feet from the rock, and on this a shed was placed containing sleeping and cooking arrangements for about fifteen men.

"The water was then pumped from the dam, and the surface of the rock within it laid bare. It was found that considerable leakage occurred from beneath. This was partially remedied, when water was again allowed in the dam, and cement and sand were thrown in, which soon hardened. On this cement bed a boiler-iron cylinder, 6 feet in diameter and 14 feet high, was placed, and between it and the wooden dam more cement was thrown in, which was allowed to harden. The water was then pumped out of the cylinder, and the leakage was found to be small."

The sinking of the shaft was then immediately commenced (December 7th). Only one man could work in it at a time. The hoisting of the *débris* was at first done by manual labor. After the excavation had been made to the depth of about 10 feet, it was found that the water came through the rock at an inconvenient rate, and a second boiler-iron tube of a slightly less diameter was telescoped into the first one, and cement was run in between it and the rocky surface of the shaft. This was repeated in the progress of the excavation, a third cylinder, slightly less in diameter than the second, being found necessary. The lower portion of this lowest iron cylinder was $14\frac{1}{2}$ feet below the upper surface of the rock.

At the end of December, 1869, the bottom of the shaft was 22 feet below low water, and early in January, 1870, the depth



THE EXPLOSION AT BLOSSOM ROCK.

was increased to 30 feet. The leakage into the shaft was now nearly checked. Drifts were then run in the direction of the longer and shorter axes of the rock. Steam was now used for hoisting, and a swinging derrick (like the one shown in Fig. 4) was constructed, which hoisted the tub containing half a cubic yard of the excavated fragments and dumped the contents on the eastern slope of the rock. Much of this *débris* was carried away by the tides. The work progressed so favorably during January that eight miners found space to work in the drifts, which had been run for a lineal distance of 130 feet. The rock had easily been picked off, and but ten pounds of powder (giant) were used in excavating the whole of the interior portion of it.

During February there was space enough in the various drifts to work sixteen miners. The drifts were enlarged and connected, and the interior of the excavation now had the appearance of a large chamber, having an arched roof supported by a dozen columns of rock. The average thickness of the roof of this chamber was about $14\frac{1}{2}$ feet.

During March the chamber had increased in size so that its greatest height was 12 feet, greatest length 135 feet, and greatest width 55 feet. The rock columns which previously supported its roof were then all removed with the exception of four near the shaft, and their places were supplied by timbers from 8 to 10 inches square, on top of each of which a sill was placed, and between the roof and sill wooden wedges were driven. (Fig. 8.) Water percolated through the rock in small quantities, but a small steam-pump placed in the chamber near the shaft kept the floor of the excavation quite dry. With sixteen men at work in the interior of the chamber, the average day's work was about 50 cubic yards of stone.

The only tools used to loosen the stone were the ordinary steel-pointed pick, gad, and sledge. In a few instances, in the early part of the progress of the work, small blasts of giant powder were used, which did good service. During the early part of the month of April quite a heavy earthquake shock occurred, though it did not damage the rock in the least.

"The inner excavation was almost completed, when some of the miners, in trimming down its edges, struck gravel, which had been rounded by the action of water, and which appeared to be cemented together in a bluish clay. This circumstance frightened them, and many of them left. The crust of the rock when the gravel was struck was about 15 feet thick, through which some streamlets of water entered, though not enough to impede the work, as the pump was sufficient to check the water. This place was propped up, and excavating in that direction ceased."

PREPARATIONS FOR THE BLAST.

On the 20th of April, 1870, the contractor ceased excavating. The size of the chamber was then 140 feet long, by 60 feet broad, with a maximum height of 12 feet, and preparations were at once made for putting in the powder. The position of the charges and the detailed arrangements of the torpedoes are shown in Fig. 12. The kind of powder used was a nitrate of soda powder, as it was less expensive than ordinary gunpowder. A quantity amounting to 43,000 pounds was used in the various charges. The vessels for containing it were thirty-eight ale-barrels, of an average capacity of 60 gallons each, and seven old tanks made of boiler-iron, securely riveted. The iron tanks varied in size from 5 to 7 feet in length, and from 2 to $3\frac{1}{2}$ feet in diameter, and contained from 80 to 175 kegs of powder of 25 pounds each. The inside of the barrels was coated with asphaltum. It was run in while hot; the barrels were then rolled over, and afterward placed first on one head, then on the other, until the inner surfaces were covered. The outside of the casks was coated with the same preparation.

In the centre of one of the heads of each cask a hole was bored, into which an iron gas-pipe tube, $1\frac{1}{4}$ inches in diameter and about 3 feet in length, was tightly screwed, and so placed that the lower end, which was plugged up, was within 6 inches of the bottom of the barrel. That end of the tube which is outside of the barrel had another tube of the same diameter screwed on to it, which terminated with a right angle to the right and left (the whole like the letter T), the length being, in all, 5 or 6 inches. The two ends were cut with screw-threads, the object of which was to receive couplings to which air-tight India-rubber tubes were fastened. These rubber tubes were made of sufficient length to be fastened, in a similar way, to the barrels to the right and left; and in fact all the barrels and tanks were connected in that way, and finally a piece of rubber tube passed from the last torpedo, through the shaft, to the crib above.

Nothing has as yet been said about the arrangement of the wires, and the charging of the barrels and tanks. Two long wires, one insulated, pass through the whole system of rubber tubes and their intermediate connections, and are eventually led up to the crib. An Abel cartridge is now placed about the middle of the gas-pipe tube, which is in each barrel, and from the cartridge lead two wires, each about 22 inches long, one of which is fastened to the long insulated wire, and the other to the other long wire, as shown in Fig. 14.

That portion of the gas-pipe tube which was within the barrel was perforated with holes $\frac{1}{4}$ of an inch in diameter, and about 4 inches apart. This tube was filled with rifle-powder. The barrels were filled through the bung with the nitrate of soda powder. By this arrangement it was supposed that when a cartridge was ignited, the quickly-acting rifle-powder would ignite the more slowly-acting soda powder in many places, thus insuring the burning of all of it. When filled the barrels were securely plugged, and an iron hoop was driven around each of them over the bung, to prevent it from being driven into the cask from the pressure of the water tamping when the chamber and shaft were filled with water.

The wooden-cask torpedoes were placed against the edges of the excavation and about 8 feet apart. The iron-tank torpedoes were distributed in the interior near the rock columns. When all were in position it appeared as though each torpedo was connected with the adjoining ones by an India-rubber hose. Each torpedo was braced and fastened in position by means of timber, so that when the chamber became filled with water they would not float about.

It was feared that when the water was introduced into the chamber its pressure would crush some of the barrels, unless some counteracting force prevented. An air-pump was, therefore, brought into requisition. In order to see that there was no leakage, air was forced through the hose to the various packages of powder. The test was satisfactory.

THE GRAND EXPLOSION.

All the arrangements having been completed, it was publicly announced that at noon of April 23d, 1870, the explosion would take place, and immense crowds collected on Telegraph Hill, and other prominent places in the city, to witness the novel sight. On the morning of that day a hole about 5 inches in diameter was cut in the iron case about 2 feet above low-water mark. As the tide rose the water flowed through the hole, and at noon of that day the chamber was two-thirds full of water. The indicator of the air pump at that time indicated a pressure of 5 pounds to the square inch.

"At 2 P.M., every thing being ready, an insulated wire was connected with the one brought up through the hose (the end of the other wire being in the water) and a boat containing the Beardslee's magneto-electric battery and the coil of insulated wire pushed off from the crib, paying out the wire as we proceeded. When about 800 feet from the crib the wire was cut and the end connected with one of the poles of the battery, the circuit being completed by a wire connected with the other pole dragging in the water. One turn of the battery-crank, and the explosion instantly follows. A column of water, variously estimated at from 200 to 300 feet high, rose majestically in the air. The diameter of the body of water thus thrown up was probably 200 feet. Around the base of this column was another simultaneous outburst of water, probably 70 feet high, whose flood seemed to roll outward. High above the mass of water could be seen rocks and pieces of timber. The highest jet of water was that which came through the shaft, and appeared as black as ink."

An examination made shortly after the blast showed that the shoalest part of the water over the rock was but 14 feet deep at mean low tide. As this shoal place was of but small area it was thought to be the old dump pile, as a pole could be thrust for several feet into the mass of broken rock of which it was composed. It was also thought that the tides would carry off a considerable portion of this broken mass; but, after waiting several days and again examining the locality, it was found to be in nearly the same condition as immediately after the blast.

It was therefore necessary that the contractor should take some active steps toward removing the *débris*. For that purpose he constructed a rake. (See Fig. 16.) It was made of heavy wrought iron, weighing $2\frac{1}{4}$ tons, and its general appearance was that of an ordinary garden-rake, except that all its parts were very much heavier. It was 8 feet wide. Each tooth was about 28 inches long, and slightly curved, with a width of 3 inches, and an average thickness of about 5 inches. The space between two teeth was 2 inches. Its handle was of heavy iron and about 8 feet in length. When ready for use it was lowered through the well, which was in the middle of the scow (Fig. 15), by means of three ropes, two of which passed over a windlass at the rear part of the well and were fastened to the two sides of the rake, while the third rope, coming from a point on the front part of the top of the well, was attached to the handle of the rake. While in position the handle of the rake was horizontal and its teeth nearly vertical. To prevent its sagging to the rear when the scow

was moved forward, a chain was attached to each side of it, and the two led forward to the bow of the scow, where they were fastened.

When a steam-tug attached to the scow was moved back and forth over the rock, the rake generally scraped the *débris* into deep water, and the depth of water over the rock was increased a few feet. Occasionally pieces of timber would float to the surface, and as they all proved to have been part of the crib-work, packages of powder were placed on the surface of the rock and exploded, with the hope of breaking up the remainder of the crib. The result was that numerous other pieces, varying from a few inches to 12 feet in length, were disengaged from the mass of the *débris*, and came up to the surface. This led to the conclusion that, at the time of the explosion, the lower part of the crib-work, which consisted of a box filled with 200 tons of rock, must have broken in two, and fallen down bodily into the crater which the blast had produced. In raking over the rock, the small, loose pieces of stone would be dragged along until the rake came in contact with the interlaced timbers of the crib-work. This would temporarily check the progress of the tug, and it was supposed that it caused the rake to jump over the obstacle and form a new dump. A diver was several times sent down on the rock. He stated that it was broken to pieces, the largest of which would not measure more than half a cubic yard, and that their average size was about that of a hen's egg. He moreover reported that at his last descent he could find no timber. Charges of powder, varying from 25 to 75 pounds, were occasionally lowered to the spot and exploded, with results similar to those of previous blasts. At last, on the 25th of May, 1870, the contractor informed us that he thought he had obtained the requisite depth of water.

It, however, required considerable additional raking to find and remove small lumps of rock that projected above the level of 24 feet; the survey to determine whether the work had been fully done was also difficult and tedious.

From time to time, during a few months after the blast, the contractor requested that an experiment be made, which was done, resulting in determining that the necessary depth of water had not been obtained. In the mean time, the method of testing the depth of water by means of the rake was not satisfactory to all the parties interested, and Lieutenant Heuer devised what he called a boom. (See Fig. 19.)

Two pieces of timber, each about 25 feet long and 12 inches square, were nailed to two cross-pieces of timber in such way that the space between the two long pieces was about 2 feet. These cross-pieces were secured at points about 5 feet from the end of the logs, and the whole constituted the floating or buoyant part of the apparatus. On the cross-pieces, and midway between the logs, holes were bored, corresponding with those in two cast-iron cylinders, standing on flat rectangular bases, which were screwed to the cross-pieces. The cylinders were 7 inches high with an interior diameter of $2\frac{1}{16}$ inches, the thickness of the iron being $\frac{1}{4}$ inch. Through the cylinders and the holes through the cross-pieces, gas-pipes, 2 inches in diameter and 30 feet long, passed. The gas-pipes hung vertically, and could be fastened at any desired depth by set screws attached to the cylinders. The lower end of each pipe terminated in a T, through which a bar of iron, 30 feet long by 2 inches in diameter, passed and was fastened. The gas pipes were graduated, and when both were lowered the same distance, the iron bar was horizontal. Experiments were made with this apparatus, referring the soundings to the contractor's gauge.

On the 7th of December, 1870, the boom was set to the proper depth of water; on it stood Lieutenant Heuer with a lead line in hand, and the apparatus was very slowly and frequently towed over the rock, until every portion of it must have been passed over by the boom. The boom did not strike the rock, and every sounding indicated 24 or more feet of water over it at mean low-tide. On the following day the work was accepted, and the contract money paid to the contractor.

Mr. Von Schmidt deserves a great deal of credit for the work he has achieved. His daring character is shown by his accepting a contract in which he was to receive no money until the completion of an experiment, the success of which could only be decided by the United States as the sole arbiter. The energy with which he pushed forward the work until the explosion took place, and the renewed energy with which he pursued his labor under such discouraging circumstances, deserves the success he attained.

ARTIFICIAL PREVENTION OF FROST.

THE Amador, Cal., *Ledger* says: "William Avala, who owns perhaps the largest orchard around here, has this year adopted the plan of keeping fires burning on the windward side, the wind carrying the smoke and heated air over the trees, and preventing the formation of frost. On an April Monday morning we were favored with a nipping frost, which we are informed has inflicted serious damage upon the fruit. Avala that morning had 120 fires burning on his garden of 50 acres, and he reports his fruit uninjured. The cost of the experiment is inconsiderable. It is rarely necessary to light up more than three or four times in a season, and the cuttings from the vines and trees are about sufficient for the purpose. He calculates that this simple precautionary measure will save him something like $1000."

The importance of this safeguard against loss by frost is vital to our fruit interest in many parts of the State. The cost of saving the fruit cannot be compared with loss which is occasioned when it is ruined. It is of special value that the remedy is so cheap and so easily applied. We trust that our fruit-growing readers in exposed situations will save up their rubbish during the coming season, and be prepared to give the frost a warm reception next spring. There is money in saving a crop just at a time when negligent husbandmen are cropless.

FALL OF A METEORIC STONE.

THERE was lately exhibited in Wolverhampton Eng., a meteorolite, weighing 80 lbs. It is believed to have fallen on April 20, 1876, in a turf field in a meadow near the Wellington and Market Drayton Railway, about a mile north of the Gradgington station. It is stated that about ten minutes to four, within a seven miles' radius of the Wrekin, the villages were alarmed by an unusual rumbling noise in the atmosphere, followed immediately by an explosion resembling the discharge of heavy artillery. Rain was falling heavily throughout the afternoon, but there was neither lightning nor thunder. About an hour after the report, a Mr. George Brooks went into a meadow, which is in the occupation of his step-father, Mr. Bailey, and noticed that a hole had been cut in the ground. He probed it, and found that what was apparently a hard stone had buried itself in the ground to a depth of 18 in., passing through 4 in. of soil and 14 in. of clay. It rested upon the gravel underneath these. The stone was dug up and removed to Wolverhampton, where it was found to be a mass of meteoric iron. The hole (which has been protected for further examination) is almost perpendicular, and the meteorolite is assumed to have fallen in a south-easterly direction. Laborers were at work at the time close to the spot where the meteorolite is supposed to have fallen, and were greatly alarmed. It is stated that the meteoric stone when found by Mr. Brooks was quite hot, although nearly an hour had elapsed from the time of the explosion being heard.

THE ERRORS OF OCULAR ESTIMATION.

WE give herewith a number of engravings as actual examples intended to prove to the reader the curious errors which every one is likely to make in mere ocular estimation of distance and position. To the draughtsman a knowledge of this defect of eye and brain is valuable, for it may cause him to rely when accuracy is required less upon the eye and more upon absolute measurements; while, on the other hand, it may have the contrary effect of showing him that certain combinations of lines which at first sight appear misplaced, are absolutely true and correct, and *vice versa*. The eye in fact has a curious way of jumping at conclusions, and when it is given two objects to compare, with one of which there is some standard of measurement, while with the other there is none, it will, as a rule, apply the standard too broadly, and assert that the one which—if we may use the term—it thinks it measures is the larger, when actually the two are equal, or when exactly the reverse of the conclusion is the case.

A good instance of this is given in Fig. 1. It will naturally be judged that the distance *a b* equals *b c*, when the fact is that *a b* is the greater. An even more striking example is shown in Fig. 2. Almost any one would be sure that the set of lines A is narrower than the set B, and further that A is higher than it is broad, and B just the reverse. Yet both sets are included in perfect and precisely equal squares—a fact easily demonstrated without measurement by turning the page so that the edge instead of the bottom is toward the observer, when exactly the reverse conditions to those above noted will be seen.

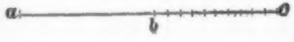


FIG. 1.

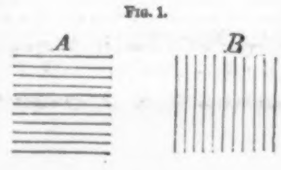


FIG. 2.

The same is true of angles, as shown in Fig. 3. The angles 1, 2, 3, 4 are each of 90°, but 1 and 2 appear slightly acute, and 3 and 4 obtuse.

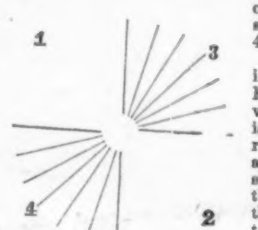


FIG. 3.

Another very common illusion is represented in Fig. 4. Naturally one would say that the line *d* is a prolongation of *a*. A ruler, however, laid against the latter line will show that *f* and not *d* is the true prolongation, although *f* appears much too low. In Fig. 5, where the same figure is drawn on a smaller scale, this discrepancy is still more apparent. The fine line in C would certainly seem to be straight, and in B the two portions appear anything but parts of a single straight line, and yet the reverse of the above is true. If the reader will hold this page off at arm's length, moving it from him gradually, he will notice on regarding Fig. 4 attentively still another odd illusion; namely, that the further the page is removed the more must the line *f* apparently be lowered in order to satisfy the eye that it is a prolongation of *a*.

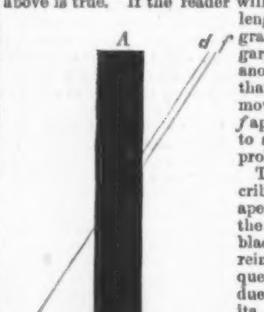


FIG. 4.

These last effects may be ascribed to irradiation. Near the apex of the two acute angles the diffusion circles of the two black lines touch and mutually reinforce each other. Consequently the image on the retina due to the thin line presents its maximum obscurity nearer to the broad band, and deviates on that side. There is, however, still another cause of the phenomenon which will be noted further on.

In Fig. 6 the lines *a b c d* in both diagrams are exactly parallel, although in the upper one they seem inwardly concave, and in the lower one convex. A still more striking example is found in Fig. 7 devised by Professor Zöllner.

The black vertical bands of the figure are relatively parallel, but they appear convergent and divergent, so as always to recede from the vertical in a manner inverse to the direction of the oblique lines which intersect them. At the same time the parts of the oblique lines are relatively displaced, as was the case with these lines in Fig. 4. If the figure be turned so that the heavy vertical lines present an inclination of 45° to the horizon, the apparent convergence becomes more striking, while the deviation of the oblique lines, now perpendicular and horizontal, becomes less marked.

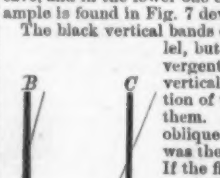


FIG. 5.

These illustrations may be considered as new applications of the rule already indicated, according to which the acute angles being of small size clearly limited, nevertheless appear too large when we compare them with undivided obtuse or right angles. Hence, if the apparent augmentation of an acute angle occurs in such a manner that the two sides appear to separate or open, the illusions shown in Figs. 4, 6, and 7 may easily result therefrom.

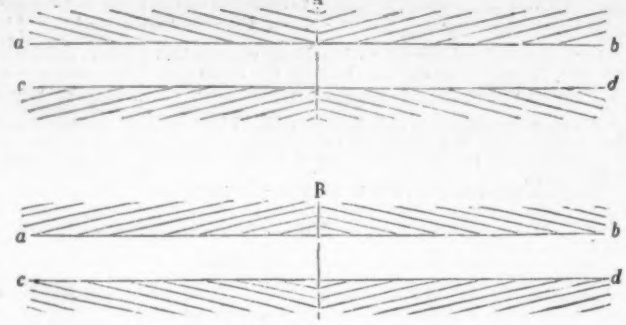


FIG. 6.

In Fig. 4 the thin lines would appear to turn around the point where they penetrate the thick band, and would consequently disappear on the prolongation, the one of the other. In Fig. 6 the halves of each of the two right lines appear deviated over the whole length, so that the acute angles which they form with the oblique lines appear enlarged. The same effect is manifested for the vertical lines in Fig. 7.

In the cases of Figs. 6 and 7, Professor Helmholtz has pointed out that the law of contrast is not sufficient to explain the phenomenon. According to him, the effect is due to movements of the eye. In fact, the illusions disappear completely when a point is fixed for the development of an accidental image, and when an image of this nature is clearly obtained. Take any point in Fig. 6 and look fixedly at it for a brief interval, and no concavity or convexity of the horizontal lines will appear. Gaze steadily along the line *a d* in Fig. 4, or consider Fig. 7 to be white lines on a black ground, and regard it thus, and in both instances the illusion vanishes. But the instant the eye is left free to wander over the design, it falls headlong into the blunder again. Perhaps we shall make our meaning clearer if we ask the reader to cover any one of the figures with a sheet of paper, then with the sharp end of his pencil to touch any point on the same above the diagram. Now stare fixedly at the pencil-point, and pull away the paper. The image which the diagram will impress upon the eye will seem perfectly correct and true.

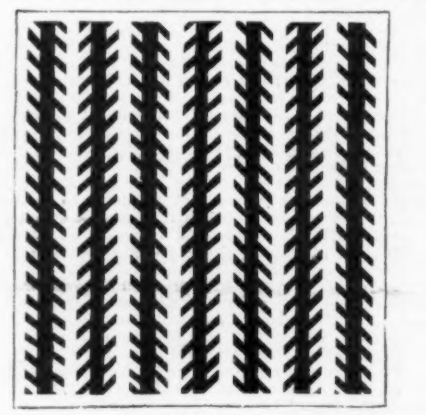


FIG. 7.

The most scientific way of proving the illusion is to illuminate the diagram so suddenly that it flashes upon the retina, and is gone before the eye fairly has a chance to move. This is done by the electric spark, to employ which an apparatus is arranged, as shown in Fig. 8. It consists of a box of wood, A B C D, blackened inside. Two apertures, *f* and *g*, are made on opposite sides. Before the hole *g* the design to be observed is fixed, and a pin-hole is made in it, upon which the gaze is concentrated; *h* and and *i* are the conducting wires. In the middle of the box is a screen, which conceals the electric spark from the eye of the observer and reflects the light upon the design.

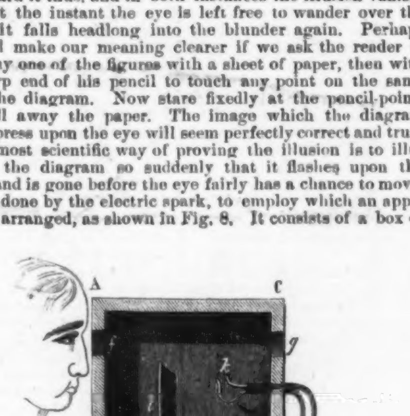


FIG. 8.

When the spark is made, the illusion persists for Fig. 4, while it completely disappears for Fig. 6. In Fig. 7 it never entirely disappears, although it is less perceptible than is ordinarily the case, despite the distinctness with which the object can be seen. We have therefore clear evidence of two distinct phenomena—first, the illusion which may be produced without the intervention of movements of the eye; and, second, the increase of that illusion by said movements.

Artists in all ages have known of these peculiar linear illusions. In Pompeii, mural paintings have been found, in which lines have purposely been made, departing from parallelism, in order to satisfy the eye influenced by other lines. Engravers also often have to study the effect of angular line-shading on straight boundary lines to prevent apparent error in their work, and draughtsmen also frequently have to exercise like care in determining the direction of the inclined lines used to indicate sections of objects.